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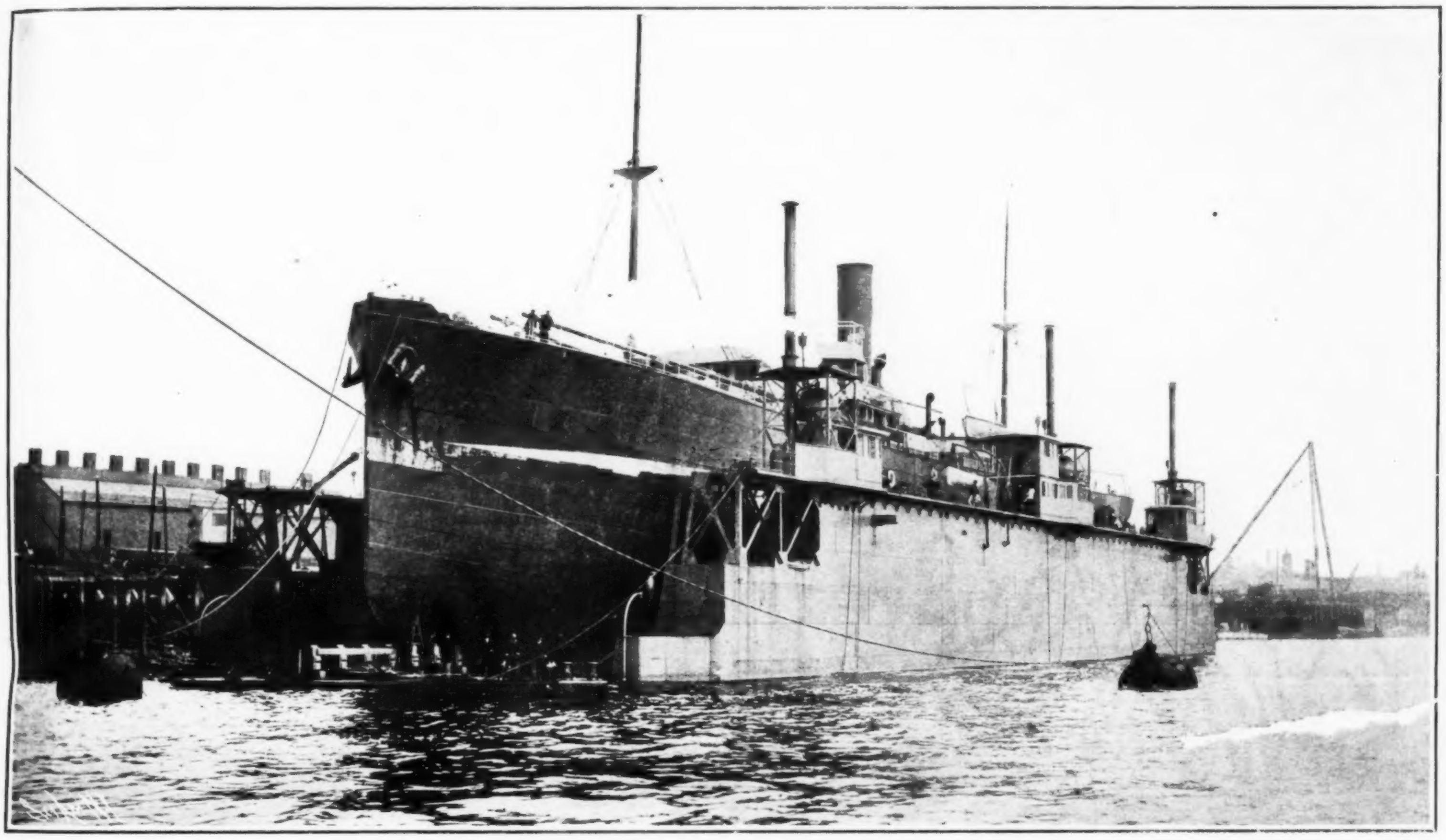
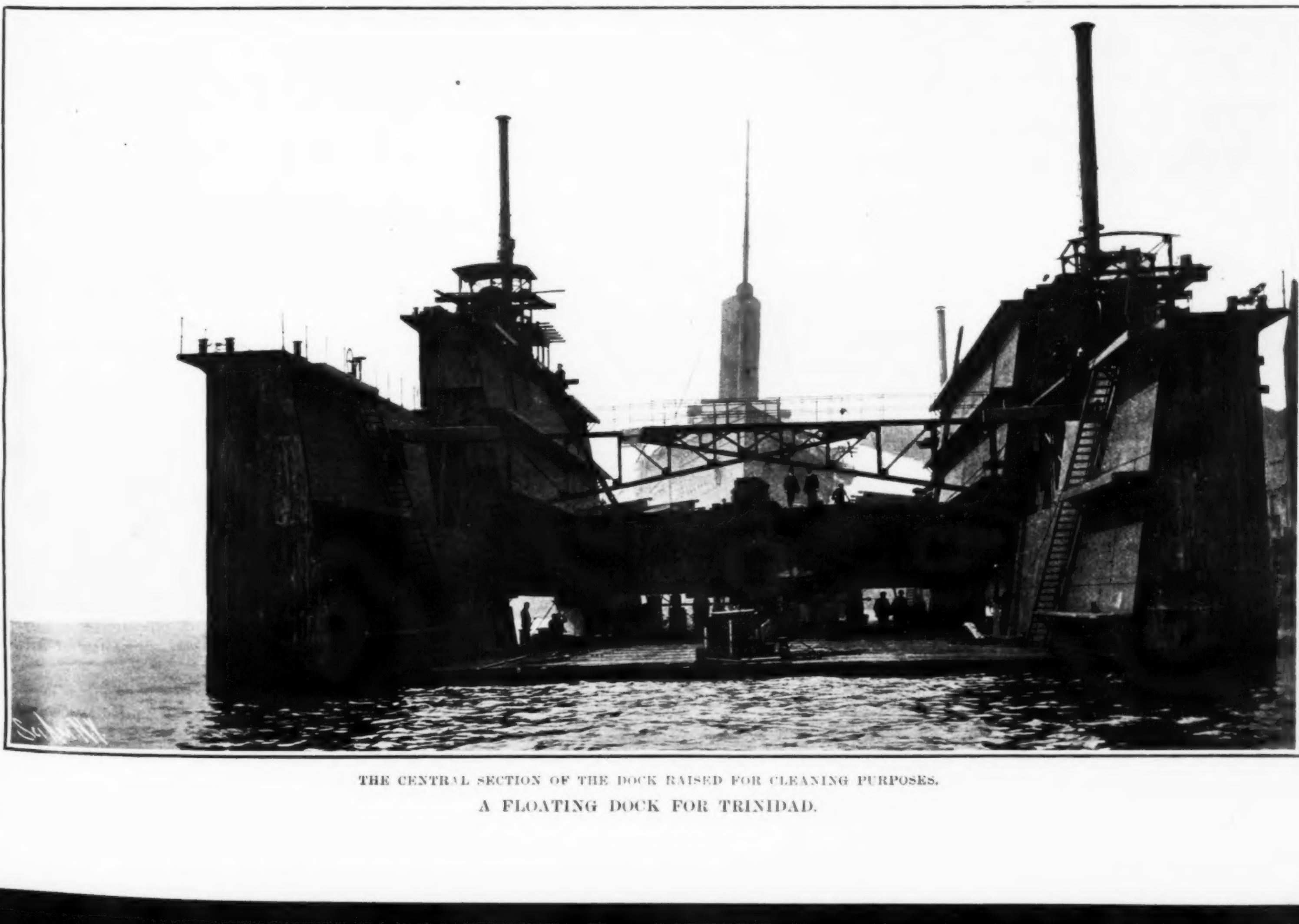


THE TESTING OF THE DOCK; RAISING A 3,100-TON STEAMER IN 70 MINUTES.



THE CENTRAL SECTION OF THE DOCK RAISED FOR CLEANING PURPOSES.

A FLOATING DOCK FOR TRINIDAD.

A FLOATING DOCK FOR TRINIDAD WONDERFULLY EQUIPPED.*

BY HAROLD J. SHEPSTONE.

The efficiency of the floating dock has long been admitted, and hardly a month now passes without another being added to the long list of these useful craft. The latest is one recently constructed by Swan, Hunter & Wigham Richardson, Limited, of Wallsend-on-Tyne, England, for the British island of Trinidad, north of the mouth of the Orinoco, in South America. The dock can claim to be the strongest structure for its type and size so far built.

It was erected by the builders from the designs of Messrs. Clark & Standfield, London, who were instructed by Messrs. Coode, Son & Matthews, the consulting engineers to the crown agents for the British colonies, to produce a floating dock of great longitudinal stiffness. The dock consists of three sections of approximately equal lengths, which are rigidly connected together into a whole. The sections are bolted together in the underwater portions, but riveted in the walls and upper portion. The strength of this form of joint, running as it does all around the ship and the dock, is very great, and indeed in the present case its resistance is equal to that of the net section of the dock itself, so that when connected up the latter may be considered as a "solid" or "box" dock.

THE COMPLETED DOCK AFTER UNDERGOING TRIAL.

A FLOATING DOCK FOR TRINIDAD.

It is the first time, however, that this method of jointing in the case of floating docks has been followed in England. That it has much to commend it is obvious, for it means that the finished structure is virtually as strong as if it were in one solid piece, though made up of sections.

The length of the dock is 340 feet over the pontoons, or lifting portion, but steel working platforms are provided at each end, bringing the over-all length of the floor up to 365 feet. The clear width of the entrance between the rubbing timbers is 62 feet, but as these timbers are carried on painting stages projecting about 3 feet from the face of the walls, there is a greater clearance for work than would be apparent from the width of entrance. The lifting power of the dock is 4,000 tons in fresh water, and it has been designed to take vessels drawing normally 16 feet of water over keel blocks 4 feet high, but a sufficient freeboard has been given to the walls to enable the dock to be sunk to a further couple of feet if a vessel of abnormally deep draft be met with.

Like all modern floating docks, it is self-docking. To perform this operation, the three sections that make up the structure are disconnected, and the two end sections are turned round end for end, so that their ends come opposite to the central section, which is square ended. They are then lowered under water, and drawn in under the central section. On pumping out the end sections they rise, bringing up with them the central section, which is then resting on their pointed ends.

So far as equipment is concerned, the dock is wonderfully complete. The pumping plant consists of three separate installations, each comprising a boiler, engine, and pump, the boilers and engines being placed in houses on top of the deck. The pumps are placed as low as possible to the bottom of the walls. The three separate pumps are all connected together by a common cast-iron main drain, which runs the full length of the wall, and from which the different compartment pipes branch off. It is, therefore, possible to utilize all of the three engines and pumps in lifting a ship; or two, or only one, if the dock is being brought up light; and in the same way, if one, or indeed two, of the installations were to break down, the third would still be capable of lifting the dock by itself. There are 72 keel blocks down the floor of the dock, 26 sliding bilge blocks, 13 on either side of the keel blocks, four mechanical side shores, and four accommodation ladders, as well as the usual valve and engine houses, capstan, and accommodation for engineers and crew.

By contract the dock was to be capable of lifting a vessel displacing 4,000 tons in two and one-half hours. At her test she picked up the Elder Dempster Line steamer "Nembe," of about 3,100 tons, in seventy minutes, from which it is clear that the dock is more than capable of doing its contract work. Directly after her trials she left the Tyne in company with tugs for her destination, where she arrived safely.

* Specially prepared for the Scientific American Supplement.

THE DEVELOPMENT OF JAPANESE SHIPBUILDING.

The war has given a great impetus to the shipbuilding and dockyard industry in Japan, which has made remarkable progress during the last few years. The principal shipbuilding yards are at Osaka, Kobe, and Nagasaki, and all three are full up with orders. The total area of the Osaka yards is about 34 acres, and about four thousand men are employed. The Kobe yards have a factory area of over 50 acres, and employ eight thousand workmen. The Nagasaki yards are the largest in the country, covering some 80 acres of land, and employing over ten thousand men. These shipbuilding yards, however, find their capacity inadequate to meet growing requirements, and are steadily engaged in extending their works. The factory arrangements have much improved. The building of torpedo destroyers is quite a new feature. Already one of these has been launched at Osaka, four at Kobe, and two from Nagasaki. The construction of gunboats for the Chinese government is going on at Kobe, two of them having already been launched. The building of ships of over 10,000 tons in Japanese yards is now quite common. At Nagasaki, a ship of 13,000 tons is being built for the Toyo Kisen Kaisha, in addition to a ship to take the place of the "Hitachi Maru," which was destroyed by the Russians during the war. According to the United States Consul-General at Yokohama, work in the smaller yards has also greatly increased since the war. The small shipyards on both banks of the Kidzugwa have hitherto devoted their attention to the building of wooden vessels of 200 to 300 tons, but these are now able to build iron ships of 800 tons. The yards at Kayokijima, outside Nagasaki harbor, which have hitherto been engaged in repairing work, are fast developing into a complete shipbuilding yard. At Innoshima, Bingo, there are two dockyard companies, one of which possesses two docks, measuring 300 feet and 364 feet respectively, while the other has a dock 410 feet in length, and is about to open another, measuring 300 feet. At Nochi and Kinoe there are two shipbuilding yards, and possessing a dock 200 feet in length. Kinoemaru has long been known as a center of wooden shipbuilding, and the launching of a ship of from 70 to 150 tons is of very frequent occurrence. The largest dock in Japan is at Nagasaki, which measures 728 feet. The next is at Yokohama, with a dock of 552 feet; the third largest at Hakodate, being 534 feet long. The floating dock, owned by the Nagasaki Company, is 412 feet in length, and is capable of floating a dead weight of 7,000 tons. Another and larger floating dock is now being built by the same company. The docking business, like the shipbuilding, is now in a very prosperous condition in Japan. The technical knowledge of shipbuilding among the Japanese has also made progress, compared with eight or nine years ago, when the "Hitachi Maru" (6,000 tons) was built. At that time, the engineers and mechanics experienced difficulty in building the steamer, but now they are able to build larger vessels with greater ease and expedition. What is necessary in Japanese shipbuilding is the further subdivision of labor among the various departments of the industry. If this is done, shipbuilding can be executed with more dispatch. There is scarcely any doubt that with the development of the shipbuilding industry in Japan orders from foreign countries will increase. Subsidies are given by the government on all ships constructed in Japan for the Japanese. The sum fixed in the budget for the current fiscal year, under the heading of encouragement to shipbuilding, is only $365,000, which is exclusive of sums paid to existing steamship lines, and Tokio papers say that it will prove quite insufficient. Speaking broadly, the rates paid for vessels built in Japanese dockyards, and satisfying the required tests, are $10 per ton for the hull, and $5 per horse-power for the boilers. Fourteen vessels, aggregating 55,488 tons, will come within the scope of the provisions, and the subsidy will amount to $1,150,000, or $1,200,000, so that there will be a deficiency of something over $750,000. The government will probably pay it out of the reserves, and embody it in a supplementary budget for the approval of the Diet next session. The tonnage under construction amounts to 55,448 tons for the fourteen vessels ordered. In addition, the Nippon Yusen Kaisha have ordered six vessels of 8,500 tons each, and there are two ships building of 2,800 tons, which will not be eligible for bounty. Thus the total under construction is 22 vessels, aggregating 112,000 tons. A subsidy is paid to mail steamers sailing not only to Europe, America, and Australia, but also to lines engaged in the coasting trade in China, in connection with Japan. These steamers run to all of the important ports in China, going not only to Corea, Dalny, Chefoo, Newchwang, Tientsin, Tsingtau, Shanghai, and all southern ports, and to the Philippines, but they go 700 miles up the great river Yangtsze to Hankow. At the close of 1903 Japan possessed 657,000 tons of steamers and 320,000 tons of sailing vessels. In 1905 the steamer tonnage had increased to 939,000 tons, and the sailing tonnage to 336,000, making a total of 1,275,000 tons. The vessels include 338 under 5 years, 331 from 5 to 10 years, 257 from 10 to 15 years, 181 from 15 to 20 years, and 131 up to 25 years, thus leaving only 148 over 25 years old.—Journal of the Society of Arts.

The new channel from Baltimore harbor to Chesapeake Bay is expected to be completed by the end of 1909, when Baltimore will be provided with an outlet to deep water 23 miles long, 600 feet wide, and 35 feet deep. The project was adopted by Congress on March 3, 1905, and work was commenced on the July 5 following.

THE DEVELOPMENT OF ARMORED WAR VESSELS.—I.

ARMOR PLATING IN THE UNITED STATES.

BY J. H. MORRISON.

THE ancients protected their war vessels at different periods with felt, lead, and later with leather; and in the sixteenth century it is claimed a Dutch war vessel was partly covered with iron. There were ten floating batteries in the Spanish fleet in the attack upon Gibraltar in September, 1782, the hulls being protected by bars of iron and covered with an outer layer of cork. The deck was housed in with a frame roof of very solid construction that was covered with heavy green hides.

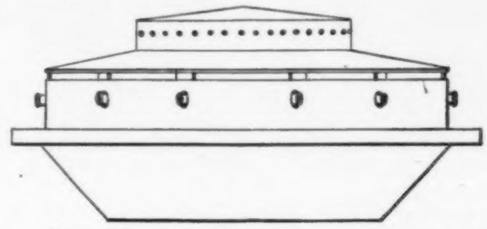
The fleet of the United States Navy at the opening of the war of 1812 with Great Britain was very limited in numbers even for a new nation, but before the close of the contest there were several wooden naval vessels added to the service, and among the number that were commenced was the "Fulton," or "Demologos," that was finished too late to be of any use in the war. This was the first war vessel that was fitted with steam power for propulsion. The report of the Commission that superintended the construction of the vessel says in part: "The main or gun deck supported her armament and was protected by a bulwark 4 feet 10 inches thick of solid timber. This was pierced by thirty (20?) port holes to enable as many 32-pounders to fire red-hot balls." This is the first instance where it is found that special provision, to such an extent, was made in a naval vessel for the protection of the crew and vessel in battle. These were truly the days of the "wooden walls."

The first trace that can now be found where it was proposed to use plate iron or sheet iron for protection on a war vessel in this country, was by Robert Fulton in 1811 in his torpedo experiments. He proposed to the Secretary of the Navy to employ in his "Torpedo War" what he called block-ships. They were to be vessels of 50 to 100 tons each, the sides of which were to be cannon proof, and the decks impenetrable to musket shot. These vessels were each to be armed with two torpedoes, each torpedo being fastened to a long spar. He afterward proposed to employ the common river sloops for this purpose, and to prepare them for it by lining them with thick timber, and *"covering their decks with pretty stout sheet iron."*

The last vessel that was designed by Robert Fulton, in 1814, was a modification of his submarine boat "Nautilus." The sides of the vessel were to be of the ordinary thickness, "but her deck was to be stout *and plated with iron*, so as to render it ball proof, which would not require so much strength as might be at first imagined, because as no shot could strike it from a vessel but at a very great angle, the ball would rebound on a very slight resistance from a hard substance. The vessel was to be of a size capable of accommodating a hundred men under her deck, and was to be moved by a wheel placed in another air chamber near the stern." The model of this vessel was approved by the Secretary of the Navy, and Fulton commenced its construction at New York, but he died before the vessel had assumed much form, and the project was soon after abandoned.

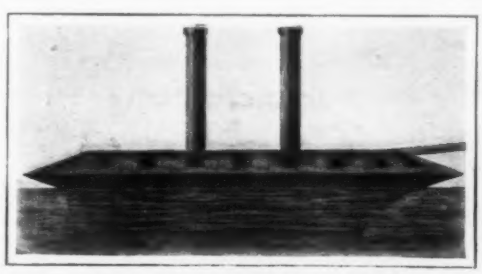
John Stevens, about 1813, appears to have been the first to design an iron-clad vessel, though this project seems to have ended in his placing his ideas on the subject on paper only, though they were never made public at the time. It was no doubt an outline of the vessel, without being fully worked out. The design as claimed was for a vessel having a saucer-shaped hull, which was to be plated with iron, and to carry a heavy battery as understood at that day. It was proposed for this vessel to be secured to a swivel, and to be held in position by an anchor in the channel of the stream to be defended. Screw propellers to be driven by steam engines were proposed to be placed below the water line of the vessel, and were to be so arranged as to cause the vessel to be rapidly revolved about the swivel at its center. There does not appear any reference to this proposed vessel during the building of the Stevens battery, that became public.

There are many features in the general design of this proposed iron-clad vessel of Stevens, that are found in a description of a floating battery designed by Abraham Bloodgood, in the "Transactions of the Society for the Promotion of Useful Arts of New York," for 1807. The body of the vessel was to be circular in form and to be held by cables and anchors in one position, while the battery was to be made to turn around on its center. It was claimed that its "rotary motion would bring all its cannon to bear successively as fast as they could be loaded. Its circular form would cause every shot that might strike it, not near the center, to glance from the surface. The guns would be more easily worked than is common, and the men be completely sheltered from the fire of the elevated parts of an enemy's ship." There is no reference made in the specifications to the vessel being plated with iron or otherwise protected. They only say that "the battery might be so strong as to be impenetrable to cannon shot, etc." This was about six years before Stevens is said to have designed his iron-clad vessel as proposed. The proposed turning of this battery of Bloodgood's around its center, preferably, it seems, by manual application, firing gun after gun as it came in line of fire, anticipated the revolving turret of later years, and should forever settle all these claims of later days to the revolving turret.

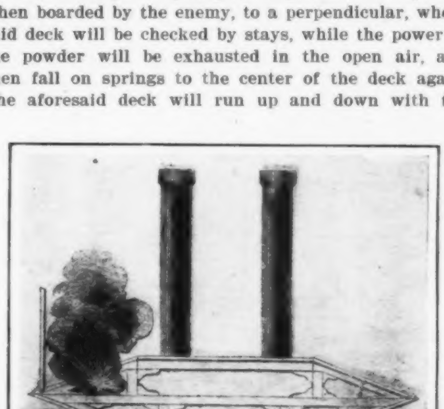


BLOODGOOD'S FLOATING BATTERY.

The first description of a bomb-proof vessel, with a cut showing the designer's idea of such a vessel, is contained in a patent taken out in this country on March 19, 1814, by Thomas Gregg, of Connellsville, Pa., for a bomb-proof vessel having a double hull, with a water wheel for propulsion in a channel between the hulls, similar to the steam ferry boats then in service at New York. The specifications of the patent say: "The boat is framed on an angle of about 18 deg. all around the vessel, where the top timbers elevate the balls, and the lower ones direct them underneath her. The top deck, which glances the balls, may be hung on a mass of hinges near the ports. Said deck is supported by knees and cross timbers on the lower side, so that it may be sprung with powder, if required, when boarded by the enemy, to a perpendicular, where said deck will be checked by stays, while the power of the powder will be exhausted in the open air, and then fall on springs to the center of the deck again. The aforesaid deck will run up and down with the angle, which may be coppered or laid with iron. The gun deck will be boarded at pleasure to give room, if required, as the men and guns are under said deck. The power is applied between her keels, where there is a concave formed to receive them from the bow to the stern, except a small distance in each end forming an eddy. The power may be reversed to propel her either way; said power is connected to upright levers to make horizontal strokes alternately. The elevation of her timbers and gearing will be proportioned by her keel and tonnage." There is in this patent some features that have been most thoroughly worked out of late years in naval vessels. From the cut it will be noticed that the rudder is located well under the long overhanging stern of the vessel, to keep it from damage by a hostile shot. The sharp stem shows it might have been intended for ramming an opposing vessel. Then there is the casemate superstructure, with the sloping walls, and portholes, the walls to be coppered or laid with iron. Some of these features were considered new and novel during the experimental stage of construction of iron clads about 1860.



GREGG'S BOMB-PROOF VESSEL.



SECTIONAL VIEW OF GREGG'S BOMB-PROOF VESSEL.

These projects were mainly brought into notice just before, and during our war with Great Britain. So far as constructing an iron-clad war vessel at that period, in this country, even to resist the artillery of that day, it would have been impossible, for the iron plating to armor a vessel was not to be obtained. Iron plate for marine steam boilers had not been rolled in this country at the time.

As it might be thought from the proposals made in these early projects "to use stout sheet iron," and to be "plated with iron," that the iron rolling mills of the country were so equipped at this period as to produce the plate iron and sheet iron for home consumption, a careful search of all data on the subject shows that our rolling mills were unable at this period to produce a plate of iron fitted for the purpose under review, and it is several years before there is any reference made to the domestic product. Wrought-iron plates were worked into stationary boilers as early as 1813 in the Eastern States; but was the iron foreign or domestic? To show what the condition of our iron industry, in general, was at this time would quote from two authorities on the subject.

There is no more valued paper on the early manufactures of this country than the Report of the Secretary of the Treasury in 1810, who says of the iron industry of the United States: "The information received respecting that important branch is very imperfect. It is, however, well known that iron ore abounds, and numerous furnaces and forges are erected throughout the United States. They supply a sufficient quantity of hollow ware, and of castings of every description; but about 4,500 tons of bar iron are annually imported from Russia, and probably an equal quantity from Sweden and England together. A vague estimate states the amount of bar iron annually used in the United States at 50,000 tons, which would leave about 40,000 tons for that of American manufacture. Although a great proportion of the ore found in Vermont, Pennsylvania, Maryland, and Virginia be of a superior quality, and some of the iron manufactured there being equal to any imported, it is to be regretted that from the great demand and from the want of proper attention in the manufacture much inferior American iron is brought to market. On that account the want of the ordinary supply of Russia iron has been felt in some of the slitting and rolling mills. But while a reduction of the duty on Russia iron is asked from several quarters, it is generally stated that a high or prohibitory duty on English bar, slit, rolled, and sheet iron would be beneficial; that which is usually imported on account of its cheapness being made with pit coal and of a very inferior quality.

"The annual importations of sheet, slit, and hoop iron amount to 565 tons, and the amount rolled and slit in the United States is 7,000 tons."

"The manufactures of iron consist principally of agricultural implements and of the usual work performed by common blacksmiths. To these may be added anchors, shovels, and spades, axes, scythes, and other edge tools; saws, bitts, and stirrups, and a great variety of the coarse articles of ironmongery. But cutlery and all the finer species of hardware and steel work are also imported from Great Britain. Balls, shells, and cannon of small caliber are cast in several places, and three foundries for casting solid, those of the largest caliber, together with the proper machinery for boring and finishing them, are established at Cecil County, Maryland, near the city of Washington, and at Richmond, Va.; each of the two last may cast 300 pieces of artillery a year and a great number of iron and brass cannon are made at that near the seat of government. Those of Philadelphia and near the Hudson River are not now employed. It may be here added that there are several iron foundries for casting every species of work wanted for machinery, and that steam engines are made at that of Philadelphia."

An American manufacturer of cut nails gives us at the same time a more practical view of the rolled iron industry of the period as affecting that branch of the hardware trade in referring to the use of imported plates and domestic plates of rolled iron for the cutting of nails.

"The fact is, that American iron, although the ore is excellent, is brought to the market and sold in an unfinished state. It is not sufficiently hammered to be sound, and it is hammered in a state so cold that the seams and cracks, of which there are many, do not close and weld. The iron, therefore, to the worker or consumer is worth by less than $10 per ton than iron furnished in the style of Russia or Sweden iron. And this is not all: for the ends of the bars of American iron are so unsound that they are only fit for scrap iron, and in fact are cut off and sold as such by the manufacturer. This being the case, and the manufacturers not being disposed to a reform, I should be sorry to be left in their hands or be subject to their pleasure, so much as I would be if our government would adopt any effectual measures to prevent the importation of iron, under the mistaken impression that our country is at present capable of producing a sufficient quantity for its own consumption."

The annual address before the Society for Promotion of the Useful Arts of New York, in 1813, confirms in effect the prior references to the iron industry. This society was one of a few in the country at the time that gave its attention to scientific subjects. It contains in part: "The ores of iron which are found in this country are for the most parts magnetic iron stone, brown hematite, and bog iron ore. The sparry iron stone has also been discovered and used. These different kinds are among the most valuable species of the mineral. They all yield an abundant percentage of ore, so as in most cases to bring a handsome profit to the proprietors. Several local circumstances conduce to this end. The cheapness of charcoal, the almost inexhaustible supply that our forests promise, the beds of coal that are continually being discovered, are all arguments in favor of our nurturing this domestic manufacture. The only deficiency that appears to originate came from the want of workmen who are sufficiently intelligent or acquainted with modern improvements. The consequence is that the iron has not been properly prepared and holds in our markets a comparatively small value on account of its inferior quality. A short period of time will doubtless remedy this defect. Men of capital and information are taking these establishments into their hands, and will press into their service American ingenuity and talents, together with all the aid emigration affords."

In a paper read before the British Association for the Advancement of Science in 1858 by George Rennie, F.R.S., an English engineer of high reputation, on "Fixed and Floating Batteries," he says regarding American experiments: "In 1821 some interesting experiments were made by order of the United States Government on seven thick wrought-iron plates ⅝ inch in thickness, fixed to a solid block of wood, and fired at with large guns and different charges, and the results were unfavorable." These experiments were more than probably made by the Ordnance Bureau of the War Department, but a search for the details of these trials has failed to find any trace of them in the department. These experiments must have been made from the favorable reports received of the experiments of Col. Paixhans in firing explosive projectiles from guns, as well as mortars, in 1819. This was the period when Robert L. Stevens said he experimented with a wooden target and shells. The largest guns we had at this time were 42-pounders, having 7-inch bore, and served with 5 to 10 pounds of gunpowder. These trials could not have been made by the Navy Department, as the Board of Navy Commissioners were too conservative for any such radical advance in naval construction, they thinking there was nothing like the stout wooden walls of a line-of-battle ship for a vessel of war. These ⅝-inch thick iron plates were no doubt hammered plates and made especially for these experiments, as there was no rolling mill that could produce the iron plates of that thickness at that time in the United States.

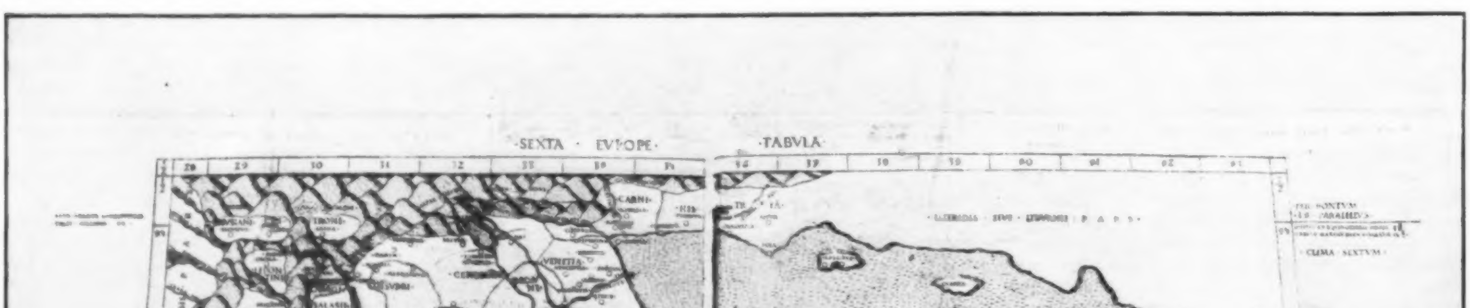
HISTORY OF MAP MAKING AND TOPOGRAPHY.—II.*

WITH ILLUSTRATIONS OF OLD CHARTS.

BY COL. C. W. LARNED, U. S. MILITARY ACADEMY, PROFESSOR OF DRAWING.

Concluded from Supplement No. 1651, page 118.

To all geographers and geodesists the size and figure of the earth has been a matter of the highest importance and interest. Eratosthenes investigated the subject and is the first who is known to have entertained clear ideas regarding it, and whose labors have the character of accurate scientific investigation. Although his results were inaccurate, due to the defective means of investigation at his disposal and the primitive state of astronomical and terrestrial knowledge, his method is the same as that used to-day—that is to say, the measurement of the length of a degree of latitude on the surface of the earth, and its comparison with the corresponding celestial arc. The Arabs in the ninth century undertook the measurement of a meridional arc in Mesopotamia; and in 1500 a Frenchman named Fernel made a crude measurement which came very near the truth. The first scientific effort in modern times to effect this determination was by Willebrord Snell, in 1617, by a measured base near Leyden, and a chain of triangulation measured by means of a quadrant and semicircles.



MAP OF ITALY.

From the geography of Claudius Ptolemy. Published in Rome in 1508.

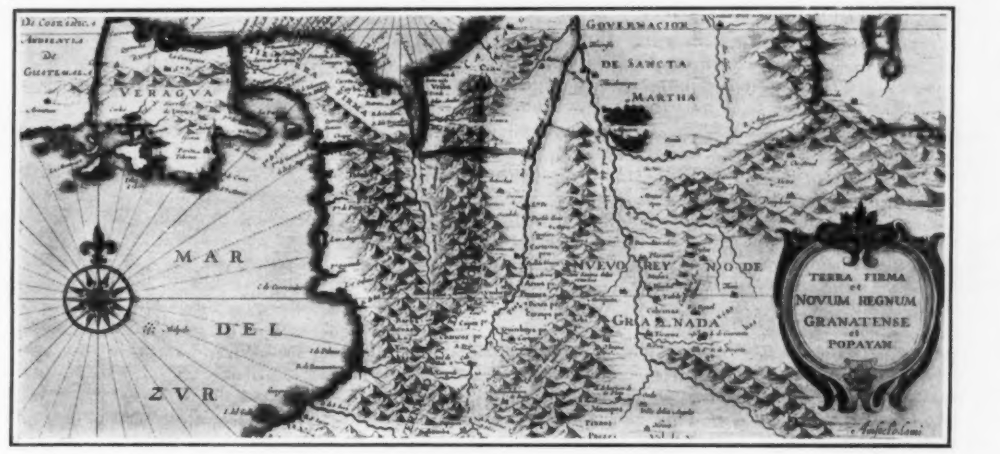
To Snell also belongs the credit of first applying trigonometry to practical geodetic operations for the double purpose of establishing geographical positions and of measuring a degree of the terrestrial meridian. His system of triangulation is practically the same as that

* Journal of the Military Service Institution.

now used in geodetic work. In 1489, however, Sebastian Munster had suggested a method of triangulation in which by the use of a divided circle, oriented by the compass for the measurement of angles and of pacing for the measurement of sides, he determined the terrestrial angle. A little later than Snell, Richard Norwood, an Englishman, took the sun's meridian altitude at two different places on the same meridian, and measured the distance between them on the public road by chain and by pacing. All these results lacked accuracy from want of an effective instrument, and were achieved without the use of a telescope. Picard in 1669, using telescopic instruments and wooden base rods, measured a line near Paris by triangulation with good results. Up to this time the shape of the earth had been assumed to be spherical, and observations had been for the purpose of determining its magnitude. A curious circumstance called attention to the fact that the earth's shape was not spherical. The astronomer Richer observed that a clock regulated at Paris lost over two minutes a day at Cayenne, and that in order to correct it it was necessary to shorten its pendulum. In the third book of his Principia Newton discusses (Propositions 18 and 19—Problem 3) the proportion of the axis of a planet to the diameters perpendicular thereto, and proves that the earth is an oblate spheroid having a diameter greater at the equator than at the poles; and in Proposition 20 discussing comparative weights of bodies in different regions he explains the phenomenon of Richer's pendulum as due to the excess of the earth's equatorial diameter, and finds the observations of Mr. Richer to coincide almost exactly with the theory of Proposition 19. An inaccurate measurement by the two Cassinis in France, in the early part of the Eighteenth century, indicated a shortening with increasing latitude of the degree of meridian arc, which would demonstrate a prolate instead of an oblate shape. This contradiction of previous observations and deductions, and the resulting discussions in the scientific world, determined the French Academy of Sciences to make an elaborate and decisive investigation of the whole matter, and gave rise to the organization of the noted expeditions of 1735 and 1736 to Peru and the Gulf of Bothnia, respectively, in order to determine the exact length of arcs at widely different points of latitude. This investigation is a classic, and resulted in the determination of a difference of approximately a mile in the lengths of the degrees measured at the two different localities—the observations of Maupertuis in the north giving approximately the length of 16 toises to a second of arc; while that of De la Condamine in Peru gave an approximate length in the south of 15.77 toises to the second of arc. This would give to a degree in the two localities approximately a length of 57,600 and 56,772 toises, respectively; or, translated into statute miles, 69.75 statute miles for the southern arc; and for the northern, 68.75 statute miles, approximately.

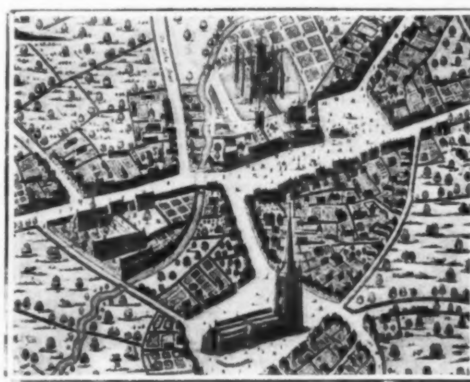
Gauss's discovery of the method of least squares, rediscovered by Legendre in 1806, and thoroughly discussed by Laplace, was applied by Bessel in 1830, to triangulation and the reduction of observations, enabling the securing of final results of extreme accuracy. The working out of the great chain of triangles in the Survey of India, begun in 1800, has been carried on by that method.

The history of modern topography begins with the use of observation by compass bearings, after the invention of the quadrant and sextant had made it possible to check the route surveys by astronomical observations. The two most remarkable and important of the early land surveys on a large scale were those of the Jesuit missionaries in China under the Emperor Kang-Hi, in 1708, of the country around Peking; and of Major James Rennell, at first an officer of the British navy, and afterward a major in the Bengal engineers and in the service of the East India Company. His survey of the Bengal region in India extended over a period of nineteen years and an area of 270,000 square miles. Rennell was a very remarkable man of indefatigable energy, and an eminent writer on geographical and topographical matters. He was desperately wounded during the prosecution of his Indian surveys, but persisted in his work while in poor health.



MAP OF THE SEVENTEENTH CENTURY, FROM "THE THEATER OF THE WORLD," BY WILLIAM AND JOHN BLAEW, AMSTERDAM, 1647.

A good example of the bird's-eye pictorial treatment of orography in an otherwise orthographic map.



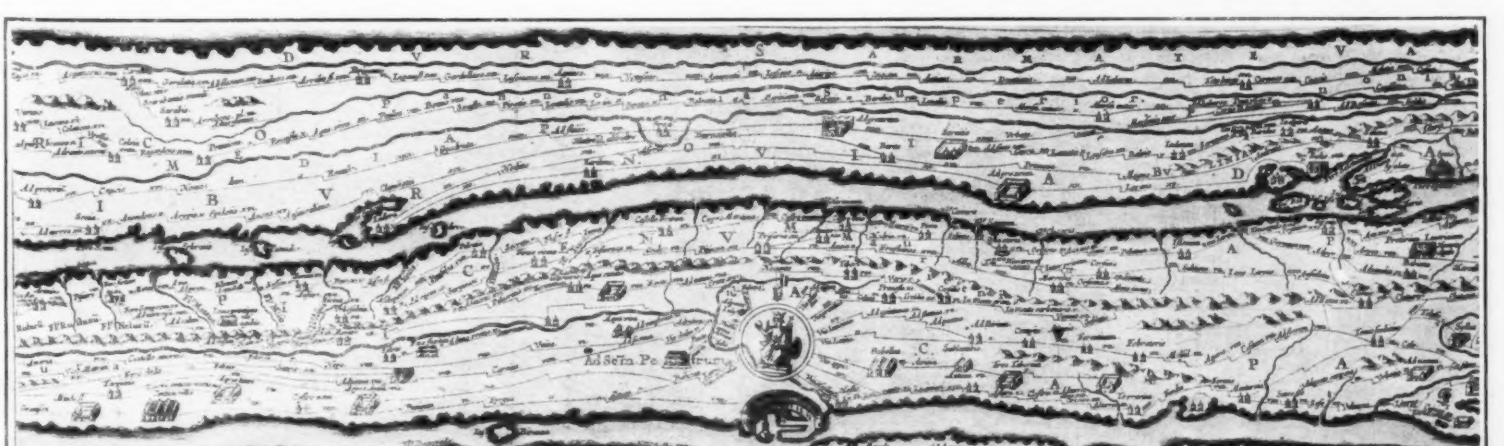
MAP OF THE SEVENTEENTH CENTURY FROM "THE THEATER OF THE WORLD," BY WILLIAM AND JOHN BLAEW, AMSTERDAM, 1647.

Pictorial bird's-eye map of an interior town with its suburbs.

toward the equator. The only method heretofore employed in Europe for the determination of location had been astronomical, by observations of the satellites of Jupiter.

In the Memoirs of Trevou* for March, 1736, reviewing Du Haldes's "Description Geographique de la Chine," it is observed:

"Nothing further remains but to say a word regarding the method, altogether exact but equally laborious, by which this great work has been executed. . . . For our missionaries, Chinese geography was a difficult science, a thorny art, an extremely laborious business. . . . The exact and purely geometrical manner in which they have executed the whole work by trigonometry alone—that is to say, by actual measurements and by triangles—resulted in rendering the work thorny, hard, frightful, inimitable, but perfect. Eight or nine hundred leagues of very irregular terrain measured, leveled and traced in ten years by seven or eight persons, with only compass and rule in hand, constitutes a regular work the most vast, the most astonishing, and, in some respects, the most capable of appalling the imagination that could have been undertaken. It came to these missionaries who were in the process of measuring the heavens and the earth, and who would find there only a clear sky and an earth entirely bare for measurement—it occurred to them, in fact, without any other purpose than to accomplish their immediate task—to measure this sky and this earth in order to make certain the correspondence to the ancient idea of a round, uniform earth which they supposed to be there. Success exceeded their hopes while deceiving them. This position was the most favorable that could have been chosen, at forty to fifty degrees of north latitude, precisely in the place where there should be the greatest inequalities if there are any. They were extremely astonished, after having measured six consecutive degrees, to find them unequal and regularly unequal.



ROMAN ITINERARY CHART, THIRD OR FOURTH CENTURY A. D., NOW KNOWN AS THE PEUTINGERIAN TABLE.

Published by Conrad Peutinger in the sixteenth century.

The survey of the Jesuits is remarkable as being the first systematically to employ trigonometrical triangulation in a large topographical survey, and to check the results by astronomical observation. They also appear to have independently discovered by actual observation the shortening of degrees of latitude Their first thought was, as it should be, that they were mistaken; but they endeavored in vain to convince themselves of error. They were not skillful enough to justify the excess of modesty which made them

* Memoires de Trevoux. Journal of Literary and Philosophical Transactions, edited by the Jesuits (1701-1705).

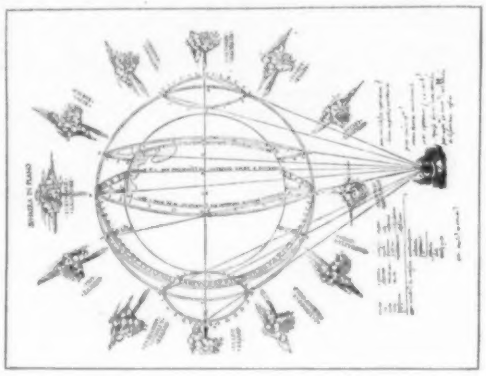
presume that they were less skillful than they were; and, after due reflection, they wisely concluded to propose to the academies and to all the savants of Europe the problem of the irregularity of terrestrial degrees, inviting them to emerge a little from their observatories and offices and to measure the earth at different localities and on the ground itself."

The problem of topographic mapping has become one of geodetic location by triangulation, verified by astronomical observation, of a series of points on the surface of the earth, connected by a chain of carefully measured triangles containing and joining together the results of more or less accurate topographic sketching which is itself controlled by minor geometric operations of measurement and location.

One by one the different governments of the world have undertaken the organization of surveys covering the territories controlled by them; and while at first these surveys have been generally more or less incoherent and widely different in method, there has been a steady tendency of late years toward a uniformity of practice in standards and conventions, and toward a high refinement in the media employed both for geodetic and topographical work. These earlier surveys have been eclipsed both in size and method by the governmental surveys undertaken by various nations, such as the government survey of India and of Great Britain; the topographical surveys of the principal Continental nations; the Coast and Geodetic Survey, the Geologic Survey, and the Lake Survey of the United States.

The Military Academy is honorably connected with the early history of exact surveying in the United States. The United States Coast and Geodetic Survey was founded under President Jefferson in 1807, and Frederick Hassler, professor of mathematics, U. S. M. A., 1807-1810, was its first superintendent. Hassler introduced the most precise instruments and methods, began the primary triangulation of the coasts, and made the first accurate topographic and hydrographic charts of the country. He was succeeded by Alexander Dallas Bache (graduated U. S. M. A. 1825) in the year 1843. Under Bache's administration the survey took on its present form, and he directed its work until his death in 1867. During these years many army officers were trained in survey work. The data collected by the Coast Survey were of incalculable value to the United States during the civil war, and most of the maps used by the army and navy were compiled in its offices.

The survey of the Great Lakes (1860-1906); of railway routes to the Pacific Ocean (1853-1860); of the territory west of the 100th meridian (1875-1879)—works of the first importance—together with numerous topographical surveys connected with campaigns of the civil war, and reconnaissances of various kinds have been conducted by officers of the Corps of Engineers. Col. Jared Mansfield, professor of mathematics, U. S. M. A. (1802-1803), and of natural and experimental philosophy (1812-1828), devised the system of



PLANISPHERE FROM THE GEOGRAPHY OF CLAUDIUS PTOLEMY, SECOND CENTURY A.D.

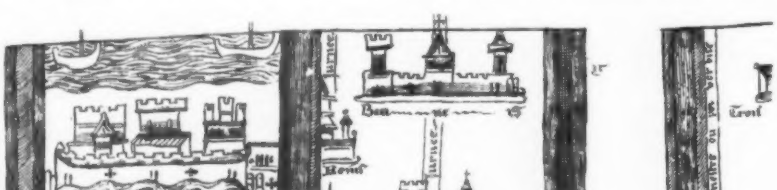
Published in Rome 1508.

surveying the public lands of the United States which is still in use. Gen. G. K. Warren's map of the western United States (1859) and its accompanying memoir are of remarkable excellence. The hydrographic survey of the Mississippi River by Generals Humphreys and Abbott (1861) is a model of its kind.

Topography is essentially a military art, and in most civilized countries of the world the government operations in topographic fields are in the hands of the War Department. Of paramount importance to the military arm at all times, the degree of that importance has greatly increased of recent years. That increase bears a direct ratio to the decrease of the power of the eye to embrace the field of operation in tactical maneuver, and to discern the locality and character of the enemy's position; and, in strategic operations, with the increase in multiplicity of the means of communication, the number and size of towns and cities, and the rapidity of mobilization of armies.

When firearms took the place of the pike in battle—so long as they remained simple in character, limited in range and visible in effect—the tactical field continued to be within the grasp of the commander's vision. The smoke of fire developed the position and character of the opposing forces, and the short range compelled the massing of contending armies. The battle was observed by the commander's eye on the spot, and the map was a subordinate, though important factor, in the determination of field operations. In proportion as these constants of battle changed in value the individual eye lost its power of control over the field of conflict, and more and more has the directing intelligence been forced to rely for information upon the accurate detail of the map and upon reconnaissance over the immediate neighborhood. Now that battles occupy in their extent an expanse of country formerly sufficient for strategic operations, the commander has become wholly helpless as a controlling intelligence dependent upon his personal powers of observation. He is now a sort of military spider at the center of a vast web of sources of information, whose threads radiate in every direction, and the material of which he must make operative through the medium of the map whose presentation of the area upon which he plays his game is the only one his eye can grasp. In the field of strategy the increased importance of a map began when war took on, under the organization of the German staff, its modern form of a science of information and precision. Since then the strategic element of war has tended steadily to pass more completely under staff control, and to become an evolution of highly perfected organization and detailed preliminary information. Campaigns are no longer planned by colossal military geniuses on imperfect data, but are coolly calculated in advance by staff groups as the result of minute knowledge of controlling conditions carefully determined and profoundly studied beforehand during times of peace. To-day the art of war endeavors to take no chances, and not to await accidental opportunities, but seeks by elaborate knowledge and profound calculation to eliminate the one and, as far as possible, to forestall or create the other. As a result of this the map—which presents the *whole field*—has taken on a degree of detail and exactness conforming to the requirements of its increased function. Exact knowledge of position has become, therefore, of more transcendent importance in proportion to the difficulty of obtaining it; and, in the same degree, of more importance to a greater number of the active personnel in warfare. The breaking up of masses, the reduction in size of practical units, the isolation of individuals have extended the necessity of knowledge of position over a largely increased number of participants. Military topography and cartography, from being the essential knowledge of a few occupying superior positions of control, has become the necessary accomplishment of the military body as a class. All holding command, whether commissioned or non-commissioned, should make it a primary study of their military education; and even the private soldier should not be ignorant of it.

Its scope of usefulness is, however, much wider than as a direct medium for information merely. Its study possesses, for the military man, an educational value quite equal in importance to that of its direct practical utility. The study of terrain familiarizes the eye with terrestrial form and its significance, and at the same time vastly increases both the habit and powers of attentive observation, than which no faculties are of more supreme importance to the soldier. To the student whose mind and eye are accustomed to the consideration of topographic form, to the minute study of terrain and landscape, as well as to the accurate observation of every variety of objective detail, there results a great increase in the scope of his mental horizon besides a vast improvement in his capacity for accurate judgment; so that the ultimate result of a thorough and painstaking study of the topographic art will be not only to increase the practical efficiency of every soldier to a very great degree, but to serve an important use in the training of his judgment and the stimulation of those mental powers which depend upon accuracy of observation and precision of statement.



ITINERARY MAP OF A PILGRIMAGE FROM LONDON TO JERUSALEM.

From the Chronicles of Mathieu, Paris, thirteenth century, preserved in the British Museum.

Lottery for Excavating Benevento.—A bill has been presented in the Chamber of Deputies providing for a $200,000 lottery, with the proceeds of which it is proposed to carry out excavations at the site of the Roman amphitheater at Benevento, the town founded, according to tradition, by Diomedes, and possessing Trajan's triumphal arch, which resembles the arch of Titus at Rome, and is the finest and best preserved of all the Roman structures. The amphitheater at Benevento is lying almost intact under a number of old houses occupied by poor people. Benevento is the capital of a province of that name, and is situated thirty-four miles northeast of Naples. In the Middle Ages it was the seat of a Lombard duchy, and in 1806 it was given by Napoleon I. to Talleyrand, who took the title of Prince of Benevento.

COMMERCE OF THE UNITED STATES BY PRINCIPAL PORTS AND SECTIONS, 1907.

SOME RECENT STATISTICS.

Ports on the southern, western, and northern borders of the United States are steadily increasing their share in both the import and export trade, while conversely, the percentage of the trade passing through ports on the Atlantic seaboard is decreasing. In 1897, 83½ per cent of the imports into the United States entered through Atlantic ports, while in 1907 the share entering through those ports will be about 80 per cent. In 1897 about 69 per cent of the exports passed out of the country through Atlantic ports, while the figures of 1907 will show but about 57 per cent of the exports of the country through those ports. These figures are based upon the records of the imports and exports by ports for the eleven months ending with May, as shown by the official report of the Bureau of Statistics of the Department of Commerce and Labor.

Comparing the figures of 1907 with those of 1906 (the figures for the closing month of the present year being an estimate based upon the known record for the month of May), Atlantic ports show an increase of but 17 per cent in imports, as compared with the immediately preceding year; Gulf ports show an increase of 18 per cent, Mexican border ports an increase of 6 per cent, Pacific ports an increase of 40 per cent, the northern border ports an increase of 12 per cent, and the interior ports an increase of 20 per cent. In exports, Atlantic ports show an increase of but 1 per cent, Gulf ports an increase of 30 per cent, Mexican border ports an increase of 17 per cent, northern border and lake ports an increase of 12 per cent, and interior ports an increase of 24 per cent, while Pacific coast ports show a decrease of about 10 per cent, this reduction in exports through Pacific coast ports being chiefly in exports to Asia, which fell in 1907 about 14 million dollars below those of 1906.

A more accurate view of the trend of the import and export trade is obtained by extending the comparisons over a longer period of time. Comparing conditions in 1907 with those of 1897, the gain in imports is apportioned about as follows: Atlantic ports, 79 per cent; Gulf ports, 220 per cent; Pacific ports, 111 per cent; Mexican border ports, 337 per cent; northern border and lake ports, 118 per cent; interior ports, 180 per cent; and for the country as a whole, 90 per cent. In exports the relative increases are as follows: Atlantic ports, 46 per cent; Gulf ports, 163 per cent; Pacific ports, 56 per cent; Mexican border ports, 193 per cent; northern border and lake ports, 211 per cent; and for the United States as a whole, about 80 per cent.

Taking up the principal ports and comparing conditions in 1907 with those of 1897, imports through Boston increased from 90 millions to approximately 128 millions, a gain of 38 millions; while exports through that port show little if any gain in the decade, the figures for 1907 being about the same as those for 1897, when the total was 101 millions. Imports through the port of New York increased from 481 million dollars in 1897 to 858 millions in 1907, a gain of 377 millions, while exports through that port increased from 392 millions to 616 millions, a gain of 224 millions. Philadelphia shows an increase from 48 millions to 80 millions, or a gain of 32 millions in imports, while exports through that port doubled, having been 47 millions in 1897 and approximately 94 millions in the year just ended. At Baltimore imports increased from a little over 11 millions in 1897 to approximately 39 millions in 1907, and exports grew from 86 millions to something over 100 millions in 1907. At Newport News imports increased from a little over 1 million dollars in 1897 to about 3 millions in 1907, while exports decreased from 22 millions in 1897 to about 14½ millions in 1907. Savannah shows an increase of about 2 millions in imports and 40 millions in exports, imports having been less than a half million dollars in 1897 and considerably over 2 millions in 1907, and exports 23 millions in 1897 and over 63 millions in the fiscal year just ended.

On the Gulf the principal ports are, stated in the order of their import and export trade in 1907, Galveston, New Orleans, Mobile, and Pensacola. At Galveston imports increased from less than 1 million dollars in 1897 to 7 millions in 1907, while exports increased from 58 millions to 244 millions. At New Orleans imports increased from 16 2-3 millions in 1897 to about 46 millions in 1907, while exports increased from 101 millions to 171 millions. At Mobile the principal business is in exports, which have grown from 10 millions in 1897 to about 24 millions in 1907.

On the Pacific coast, San Francisco shows an increase of 22 millions in imports and a decrease of 7 millions in exports, imports having advanced from 34 millions in 1897 to 56 millions in 1907, and exports having receded from nearly 40 millions in 1897 to about 33 millions in 1907. At Puget Sound imports increased from 7 million dollars in 1897 to about 25 millions in 1907, a gain of 18 millions, while exports advanced meantime from less than 12 millions to approximately 43 millions, a gain of about 31 million dollars. It is proper to add that the figures for these Pacific coast ports do not indicate all of the actual commerce at those points, because of the fact that the trade with Hawaii, which was included in the foreign trade figures of 1897, is not included in those of 1907, that Territory having become in 1900 a customs district of the United States. A large share of our trade with Hawaii (aggregating in shipments therefrom about 28½ million dollars and in shipments thereto about 14 millions) enters or leaves the country through Pacific coast ports, and this fact should be taken into consideration in determining general conditions in that section of the country. San Francisco has, in fact, increased her receipts of merchandise from Hawaii from 10 million dollars in 1897 to about 16 millions in 1907, and her shipments thereto from 4 millions to 11 millions, while Puget Sound, whose receipts of merchandise from Hawaii are inconsiderable, shows a marked growth in shipments to that territory, the gain having been from a quarter million dollars in 1897 to about 1½ millions in 1907.

This drift of the foreign trade away from the Atlantic ports and toward the ports on the southern, western, and northern borders occurs more largely in exports than in imports, and is due in part to the fact that a much larger share of the grain and cotton exported now finds its way to Europe via the Gulf, Pacific, and northern border ports than formerly, and to the further fact that the exports to the Orient, which have increased rapidly during the decade, pass chiefly out of the Pacific coast ports. In imports the gain by the southern, western, and northern border ports over those on the Atlantic front, while not so strongly marked, is due to a rapid increase in importations from the Orient, which pass largely through the Pacific ports, and the increase in movements from Mexico and Central America at the south and Canada at the north of material for use in the manufacturing establishments of the United States.

A summarization of the year's business shows that less than a dozen customs districts are credited with five-sixths of the entire foreign commerce of the United States. Stated in the order of magnitude they are approximately as follows: New York, 1,480 million dollars; Galveston, 251 millions; Boston, 230 millions; New Orleans, 217 millions; Philadelphia, 174 millions; Baltimore, 145 millions: San Francisco, 90 millions; Puget Sound, 68 millions; Savannah, 66 millions; Mobile, 28 millions, and Chicago, 25 millions. Considering imports and exports separately, the leading ports are in imports: New York, Boston, Philadelphia, San Francisco, New Orleans, and Baltimore; and in exports, New York, Galveston, New Orleans, Baltimore, Boston, Philadelphia, Savannah, Puget Sound, Detroit, San Francisco, and Buffalo.

Detailed information as to the trade of the various ports by principal articles during the year just ended is not yet available, but the character of that business may be ascertained approximately, by reference to figures for the year 1906. For that year New York was credited with about one-third of the total exports of the country, iron and steel (80 million dollars), meats (70 millions), copper ingots and bars (45 millions), mineral oils (45 millions), and cotton (30 millions), being the leading items in a list of articles including practically every branch of our export trade. At Boston the principal exports are meats (27 million dollars), cattle (10 millions), cotton (10 millions), breadstuffs (10 millions), and lard (6 millions). At Baltimore, cattle (5 million dollars), corn (13 millions), wheat and wheat flour (8 millions), cotton (9 millions), copper ingots and bars (27 millions), manufactures of iron and steel (7½ millions), lard (7 millions), and leaf tobacco (8 millions), are the leading articles of exportation. The chief commodities exported at the port of Philadelphia are mineral oils (20 millions), breadstuffs (17 millions), and meats (6 millions). At Savannah cotton constitutes the most important item of exportation. At Galveston, the principal cotton port of the country, while cotton (137 million dollars) is the leading article exported, breadstuffs (12 millions) and cotton-seed oil cake (5 millions) are items of increasing importance. New Orleans is second to Galveston as an exporter of cotton, being credited in 1906 with 93 million dollars. Corn, flour, cotton cloth, cotton-seed oil cake, cotton-seed oil, and leaf tobacco supply the bulk of remaining exports from New Orleans, their values ranging downward in the order named from 10 millions to 3 millions. At San Francisco cotton cloth (8 million dollars), iron and steel (4 millions), fruits (2½ millions); and wheat and flour, canned salmon, fruits, and cotton (each about 2 millions) constitute the principal exports. At Puget Sound the leading exports are cotton cloths (10 millions), wheat (6 millions), flour (7 millions), and cotton, iron and steel manufactures, and copper, each about 4 millions.

POSSIBILITIES OF HYDRAULIC MINING.

It is a well-established geological fact that in recent times, probably post-glacial, there was a change in the drainage channels in British Columbia, and as a result the former river channels are not the present waterways. Most of the gold in the rich placer diggings came from these old river channels through concentration by the present streams and as they are low grade they can be best mined by hydraulicking. In the Yukon Territory, north of British Columbia, near the city of Dawson, the famous White Channel deposit is estimated to contain between \$60,000,000 and \$100,000,000 in gold, but it will cost several millions of dollars to convey water to it for washing purposes; this is being done by strong American mining companies.

The gold nuggets in the rich shallow creek deposits vary in appearance in the different creeks of a single region, and it is possible for one with experience to tell with a certainty from what creeks they were taken. The nuggets from the upper portions of the streams are generally angular and large, but they become smaller and smoother as they descend the stream, owing to the increased wearing they receive. The gold found in gravel that is worked by hydraulic means is generally so fine that mercury is required to collect it. Gravel carrying six to seven cents per cubic yard cannot be profitably worked at the present time in British Columbia unless provided with railroad facilities. Gravel containing ten cents per cubic yard can be worked at a small profit; the average value of hydraulic gravel in the Cariboo region is about twenty cents per cubic yard. At a large mine in this region the cost of recovering the gold was about eight cents per cubic yard, which is about twice the cost in California, the difference being due to the greater cost of supplies and everything else connected with the work in a region remote from the railroad. Gravel as low as three cents per cubic yard has been profitably worked in California, and the same can doubtless be done in British Columbia with railroad facilities, which will be furnished in the near future. Many of the enormous banks of auriferous gravel in the Cariboo region are situated favorably for hydraulicking. Where the gravel is fine, it is liable to contain thin flaky gold, which is hard to recover. In the ordinary hydraulic gravel, which runs from ten to fifteen cents per cubic yard, a person could pan all day and not get a color, so it is necessary to use a "rocker" and thus wash four or five cubic yards to see colors of gold.

Some bars situated on the Fraser River have been worked constantly during the last forty years in exactly the same place; men are able to make wages of several dollars per day washing these bars from year to year, showing that the gold comes down the river annually in the spring floods. All of the rivers in the Fraser watershed have a flood season in the spring and an average rise of 50 to 60 feet above the lower summer stage is not an uncommon experience for the Fraser River itself.

A miner can pan carefully only about one cubic yard of gravel a day of ten hours, and therefore gravel below \$3 or \$4 a yard could not be profitably worked in this way. Occasionally a miner strikes an unusually rich gravel; one miner has been known to obtain about \$900 from a single pan of gravel in the Cariboo region, the gravel being situated on bed rock, and the succeeding pans averaged from \$300 to \$400. This, of course, is exceptional, but it is occasional pans of this value that keep up the excitement of the prospector.—Mines and Minerals.

Watertight Roofing Paper.—*a*. Paper saturated with copper oxide-ammonia fluid, several prepared sheets laid on top of one another and passed between calender rolls and dried. *b*. Paint, 35 per cent of powdered argillite, 30 per cent of powdered mica slate, 35 per cent of pulverized American rosin. Mixed in the proportion of one-half with pure coal tar and boiled.

GERMAN AUTOMOBILE FIRE APPARATUS.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

IN the way of modern apparatus, the city fire department of Hanover is one of the best equipped in Germany. At present the department uses three different forms of automobile cars, the first being an extinguisher, the second a combined hose-carriage, hook and ladder and fuel carrying car, and the third an automobile fire engine.

In the first of these apparatus water to the amount of 900 pounds is carried in a large tank which is mounted in the rear between the side-bars of the chassis. Two bottles of carbonic acid gas are placed on the back platform to furnish the needed pressure in the water tank for producing the stream. Electricity is the motive power, the storage batteries being set under the front seat. There are two separate electric motors mounted one beside each of the rear wheels and driving the latter independently. Upon the car body is mounted a double hose reel so that one hose can be unrolled at each side. On the upper part of the framework which carries the reels is a rack containing a set of ladders. The storage batteries for the car, which are contained in four long wood cases of 11 cells each, or 44 cells in all, have a total weight of 1.2 tons. Four-pole inclosed electric motors, mounted beside the rear wheels, drive these by means of small steel pinions engaging large bronze gears on the wheels. This gives a speed reduction of 1 to 8.5. The motors run on 88 volts and make 410 revolutions per minute. The car runs at the rate of 10 miles an hour and the battery charge lasts for a 15-mile trip. With the five men which the car holds, the water, batteries, etc., the total weight when in running order is 5 tons. The total length is about 15 feet, and the height 8 feet. As for the fire engine, the pump apparatus of this, which lies directly back of the driver's seat, is of the two-cylinder double-acting type and is designed for a capacity of 320 gallons per minute. Between the pump and the boiler, which is firmly fixed to the side-beams of the truck and in front of the rear axle, is placed a small steam engine having about 10 horse-power capacity. This engine is used to drive the automobile on the road. In front of the driver's seat is an operating lever by which he controls the small engine and obtains the different speeds by acting upon the valve mechanism. Sprocket and chain driving are used to connect the small engine with the back wheel on each side of the car. The chain operates a small pinion which is so placed as to drive an internal gear forming part of a drum attached to each rear wheel. The outside surface of the drum serves to take the brake bands. This method of braking, however, is only used in case of emergency.

One of the peculiarities of the new Hanover fire engine lies in the novel method of heating the boiler, which has been specially designed by Director Reichel. The oil burner system was found undesirable for different reasons, and a new arrangement was sought for which would fulfill the four different requirements as follows: The engine is to be run out at once after the alarm is given, and is to travel without any noise. During the run it is not to give off smoke or odor of any kind, and when it reaches the fire it is to have full steam pressure and be ready to deliver the water stream at once. In order to keep the fire engine always in condition to start out upon the first alarm, the boiler is kept heated by a small gas-burner which is supplied from the city mains. But in order to start the automobile, carbonic acid gas pressure is used on the small engine to drive it at the outset. The carbonic acid gas is supplied from three steel cylinders which contain compressed gas at a pressure of 25 pounds. The contents of the gas cylinders is enough to keep the small engine and the car running until they are ready to run by steam from the boiler, as the latter is fired up while *en route*. To make the engine run without noise, a condenser is provided which is located under the driver's seat and is connected to the exhaust pipe of the engine. The boiler is fired while on the way to the fire by a special form of alcohol burner. The alcohol is contained in a copper tank placed in the rear of the car, and holding 10 gallons. This tank is connected at the top with a small carbonic acid gas bottle (charged by apparatus in the station) containing gas at a pressure of about 2 pounds. From the tank the alcohol is forced by the gas pressure through pipes which convey it to the furnace opening underneath the boiler. It comes out here through two atomizer nozzles of the Körting pattern, which have 0.02-inch opening and deliver a 90 to 110-degree angle of spray.

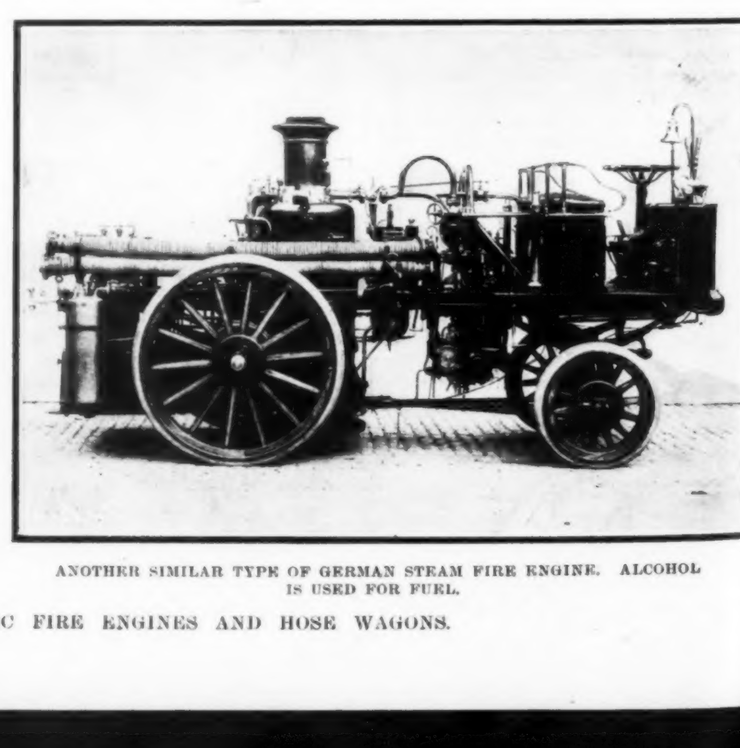
To start the alcohol burners, the valve of the gas bottle and the cocks of the atomizers are opened. As the gas burners are already running the alcohol burners are lighted at once, and then the gas apparatus is removed from the boiler before the car starts out. With alcohol burners the steam pressure can be brought up to 5 atmospheres within ten minutes when the car is running. The engine uses four or five atmospheres pressure for the normal running. After the alcohol burner has brought the steam up to the right pressure, the firing is continued while still *en route* in the following way, so as to have the engine ready to deliver the water as soon as it comes to the fire: In the rear the car holds some 25 pounds of charcoal briquettes which are entirely smokeless. To heat up the briquettes very quickly, the upper part of the furnace is provided with a third alcohol spray which is directed upon the briquettes and brings them to a bright glow within one minute, after which this spray is removed. As soon as the charcoal is burning properly, the fireman charges the furnace with peat-coke which is soon brought up to heat by the charcoal and the alcohol jets combined. It is found that alcohol alone is not sufficient to heat up the peat-coke, and hence the charcoal briquettes are needed. When the engine arrives at the fire, it is prepared to deliver steam to the pump. The firing is then continued by the use of coal or coke. With six men, water and combustible, supplies, etc., the engine has a total weight of 4.95 tons, and it makes a speed of 12 miles an hour. It has a total length of 14 feet and height of 7½ feet.

THE ELECTRIC WATER AND HOSE WAGONS, AND THE STEAM FIRE ENGINE COMING OUT OF THE NEW FIRE APPARATUS BUILDING AT HANOVER, GERMANY.

One of our engravings shows the new Hanover fire station with the three automobile apparatus. For the above information the writer is indebted to Chief Reichel, to whose efforts the present success of the fire system is largely due.

The town of Schöneberg, near Berlin, is now using

HANOVER'S STEAM FIRE ENGINE. CYLINDERS AT REAR CONTAINING CARBONIC ACID GAS FOR STARTING.



ANOTHER SIMILAR TYPE OF GERMAN STEAM FIRE ENGINE. ALCOHOL IS USED FOR FUEL.

MODERN GERMAN STEAM AND ELECTRIC FIRE ENGINES AND HOSE WAGONS.

a new automobile fire engine which we illustrate herewith. It has two engines, one of which is used for running the car and is of a 25-horse-power double-cylinder pattern, and a second of 35-horse-power, which operates the water pump and delivers 600 gallons per minute. The boiler is heated by a petroleum burner, and a regulator on the oil-feed keeps the steam pressure at the right point. The petroleum comes into a heated spiral tube, where it is vaporized and passes into the nozzles of the burner. The oil-tank holds 35 gallons, which lasts for a 15-mile run. The oil is fed under pressure by carbonic acid gas. A small flame keeps the boiler always under pressure, and when in the engine house at Schöneberg the boiler is connected to piping which brings superheated steam into it from a plant located on the premises. One of the water tanks is built so as to form the front seat of the car, while the second tank is placed under the rear. The car runs at 15 to 20 miles an hour with one man driving and the second for firing, mounted in the rear. The fire engine made a trial run from the Bautzen factory to Schöneberg, 140 miles, and it made the trip in two days without any difficulty.

THE NOVEL STEAM FIRE ENGINE USED AT SCHÖNEBERG, GERMANY.

ELECTRIC HOSE AND WATER WAGON WITH STORED CARBONIC ACID GAS FOR FORCING THE WATER.

MODERN GERMAN STEAM AND ELECTRIC FIRE ENGINES AND HOSE WAGONS.

CAMILLE FLAMMARION'S LATEST VIEWS ON MARTIAN SIGNALING.

In a recent bulletin of the Astronomical Society of France Camille Flammarion comments upon the eccentricities of wireless telegraph receivers, and in a rather guarded but unmistakably sanguine memoir gives his views on the meaning of these eccentricities. With his well-known leanings toward a theory which holds that Mars is an inhabited globe, Flammarion is not loath to regard the unaccountable behavior of wireless apparatus as an attempt of the Martians to signal to the earth, although he is baffled by the unhappy distance at which Mars is placed just at this time.

"The press of both hemispheres," writes Flammarion, "has been publishing for some months a very sensational piece of news which many a one would *like to see* discussed. It seems that at Cape Clear in the British Isles, where Signor Marconi has just established a wireless telegraph station, a message, always the same, but thus far undecipherable, is being received every day between midnight and 1 A. M.

"In this message there is no word of any known terrestrial language, and the mysterious signal must seemingly remain incomprehensible. It is, moreover, said that the ingenious inventor of wireless telegraphy has intimated that, since the message corresponds to no terrestrial language, it is perhaps sent by the inhabitants of Mars.

"The idea is original, but improbable. However, it would be a good thing to know exactly what has been observed. Perhaps it is a question of some trouble caused by terrestrial magnetism or atmospherical electricity. As Signor Marconi has not expressed any personal idea on the subject, it is probable he attaches no great importance to it. On the other hand, it would be useful to know what truth there is in the origin of this story, when the mystery began, how long it lasted, and whether really the perturbation took place at a given hour of the night. By passing successively through different periodicals of different countries, the simplest facts are transformed, twisted, and metamorphosed in the most fantastical way.

"First of all, the fact of the inhabitants of Mars choosing this year 1906 to begin communication with us is most improbable, for during the past year we have been the farthest possible from each other, as Mars has been going beyond the sun with respect to us. It is not such a situation which would be preferably chosen to bring about an *entente cordiale*. If our celestial neighbors seek to communicate with us, the most favorable time for such trials of interplanetary telegraphy would be when we are nearest to each other; for instance, in May, 1905, or July, 1907. The year 1906 is useless for such purposes.

"On the other hand, how could this message from Mars be received every night between midnight and 1 A. M., the planet not being above our horizon, but on the contrary, below the earth?

"Everything goes, therefore, toward making us believe that the inhabitants of Mars have nothing to do with this business. If, as several scientific periodicals assert, the signal received consists of three points (. . .) which represent Marconi's S, we have but to remember that Morse's telegraphic apparatus gives precisely a similar three-point mark whenever there is a high electrical tension, and to conclude that atmospheric electricity, as we said above, is the real cause of the disturbance. However, the periodical regularity of these signals (?) remains a problem. Until we receive more information we must therefore prudently reserve our judgment. The question is none the less interesting. Besides, it has not been put today for the first time.

"The idea of communicating with some other world has preferably been applied to Mars, brought so magnificently near to us by the conquest of the telescope. Intellectual life seems actually to be at its apogee in this near world, and there is nothing absurd in surmising that for thousands of years signals have been sent us by the inhabitants thereof, without our having as yet been able to comprehend them.

"Science is, as a matter of fact, quite recent on our globe. It is hardly two hundred years since we have begun observing Mars with optical instruments, and studying its geography and meteorology; and even in our day but a small number of men are doing so with assiduity. The Martians, more advanced than we in their evolution, may long since have conceived divers means of entering into communication, quite strange to us, and thence have concluded that terrestrial humanity has not made much headway from an intellectual point of view.

"Several times, it is true, we have observed luminous points on the planet; points which seemed to be signals to some, endowed with rather vivid imaginative power. A closer observation, however, proved these points to be due to natural phenomena—snow and clouds.

"Our progress in Martian geography has been so rapid these last twenty years, that we may foster bright hopes. We must not exaggerate them, however, like Madam Guzman, who, in her legacy to the French Academy of Sciences, bequeathing the sum of one hundred thousand francs to him who should find the means of communicating with a star, excepted Mars; doubtless because, in her mind, it would be too easily and too quickly done.

"Charles Cros proposed to create an artificial star, by means of an intense electrical light, directed by parabolic mirrors, and which, from Venus or Mars, might be equivalent to a star of the eighth magnitude. By varying the signals thus transmitted, the observers on Mars or Venus could attribute them only to an intelligent, and not simply a natural cause.

"The magnetic or electric perturbations in the Marconi apparatus have probably not advanced the problem, but they have invited us to think that the day will perhaps come when humanity on our floating isle will no more be isolated from fellow creatures in space."

THE ANT PEST IN NEW ORLEANS.

To the many pests, such as the brown rat or the Hessian fly, which have been transplanted to new lands by the agency of commerce, New Orleans adds a new one, an ant, which in recent years has spread until it has now become an almost universal house pest.

The Rev. Father Biever, S. J., has suggested a vigorous united campaign to rid the city of its pest. Action certainly seems urgent, for the adaptability of these little creatures allows them to nest anywhere—under the carpet in a room, or in the interstices of paneling, as readily as in a mound out of doors.

Speaking of his experiments toward extermination Father Biever says that he has achieved excellent results with carbon disulphide, an inflammable chemical which requires careful handling. Pour some into the nest and cover it with a bell jar to retain the fumes. The vapor will kill both ants and larvæ; or a similar result may be obtained with concentrated ammonia. Coal oil will instantly destroy ants, but as it is equally fatal to plant life it cannot be used on colonies at the roots of shrubs. Gum camphor or paper soaked in oil of peppermint will keep ants away; or a syrup of borax and sugar dissolved in boiling water will destroy them. Ants will readily eat of a paste composed of two parts of red lead, one part of flour, mixed with molasses; but this paste must be kept out of the reach of children, for like many of the commercial ant exterminators it is a deadly poison. Ants will not cross a surface which has been smeared with vaseline. Success in exterminating the pests, however, depends on concerted action by the community. If the inhabitants of New Orleans would unite as they did for the extermination of the stegomyia mosquito, a tangible result might be achieved. Let each family place round the premises rags saturated with honey or molasses, and when they are covered with ants steep them in boiling water. This process repeated three or four times a day for a week would almost deplete the colony of workers and jeopardize the life of the larvæ in the nest, which need constant attention.

The cultivation of bamboos on an extended scale is contemplated by the Japanese residents of Victoria, B. C. Experimental growths have proved very successful, and during the coming winter many roots will be imported from Japan. The cultivators hope to develop a big trade in bamboo furniture; and also to introduce the use of bamboos as water pipes, a purpose for which they have long been in use in the Orient. Bamboo cultivation is a profitable industry in Japan, where the returns from an acre yield from \$20 to \$90.

THE ELECTROLYTIC THEORY OF THE CORROSION OF IRON.—I.*

THE REAL CAUSE OF IRON RUST.

BY DR. ALLERTON S. CUSHMAN.

From the standpoint of the modern theory of solutions, all reactions which take place in the wet way are attended with certain readjustments of the electrical states of the reacting ions. The electrolytic theory of rusting assumes that before iron can oxidize in the wet way it must first pass into solution as a ferrous ion. The subject has been interestingly treated by Whitney, who discussed it from the standpoint of Nernst's conception of the source of electromotive force between a metal and a solution. When a strip of metallic iron is placed in a solution of copper sulphate, iron passes into solution and copper is deposited, this change being of course accompanied by a transfer of electrical charge from the ions of copper to those of iron. Hydrogen acts as a metal and is electrolytically classed with copper in relation to iron. If, therefore, we immerse a strip of iron in a solution containing hydrogen ions, an exactly similar reaction will take place, iron will go into solution, and hydrogen will pass from the electrically charged or ionic to the atomic or gaseous condition. In such a system the solution of the iron and, therefore, its subsequent oxidation must be accompanied by a "precipitation" or setting free of hydrogen. It is very well known that solutions of ferrous salts as well as freshly precipitated ferrous hydroxide are rapidly oxidized by the free oxygen of the air to the ferric condition, so that if the electrolytic theory can account for the original solution of the iron the explanation of rusting becomes an exceedingly simple one.

As iron has been shown by Whitney, Dunstan, and the writer to rust in the presence of pure water and oxygen alone, the electrolytic theory as a fundamental cause of the wet oxidation of iron must stand or fall on the determination of one crucial question, viz.: Does iron pass into solution, even to the slightest extent, in pure water? If iron does dissolve, the electrolytic theory is so far satisfactory; if it does not dissolve, we must conclude that the oxygen finds some way of directly attacking the metal.

Almost everyone will admit that in the case of impure iron, with its unhomogeneous physical and chemical constitution, electrolysis will supervene, but it must be remembered that we are now concerned with the underlying cause of the wet oxidation or hydroxylation of iron, regardless of its state of chemical purity.

According to the dissociation theory, even the purest water contains free hydrogen ions to the extent of about 1 gramme in 10,000,000 liters. If iron dissolves in the purest water it should be by interchange with hydrogen, and as Whitney has pointed out, pure water is to this extent an acid. In order to get experimental evidence on this crucial point, Whitney describes the following experiment:

"A clean bottle was steamed out for a time to remove soluble alkali from the glass and was then filled with pure distilled water, which was kept boiling by passing steam through it for fifteen minutes. While still boiling, a bright piece of iron was placed in the bottle. A stopper (in some cases rubber and in others cork) carrying a tube open in a capillary several inches above the stopper was inserted into the bottle and firmly fastened in place, the water being kept boiling. Finally, the glass capillary was heated hot by means of a blowpipe and sealed by squeezing the walls together. The bottle was then allowed to cool to a temperature of about 80 deg. C., and the neck of the bottle was finally covered with paraffin to prevent leaking. It was thought that in this way the oxygen, carbonic acid, and other gases in the water were completely removed. Bottles containing iron and sealed in this manner have stood without any visible change for weeks. In some cases a little air was subsequently admitted to bottles which had stood in this way with the iron apparently unaffected, and within a few minutes the water became cloudy and assumed a yellow color. Ordinary rust rapidly deposited upon the glass and in spots upon the metal. In fifteen or twenty minutes the production of rust throughout the bottle was perfectly evident. It seemed plain from the rapidity of formation of oxide and its precipitation on the glass that the iron had dissolved in the water before the addition of the air, and that the latter simply permitted the formation of the insoluble oxide." This conclusion has been attacked, but it appears to the writer to be demonstrated that Whitney was right in his assertion that iron goes into solution up to a certain maximum concentration in pure water, without the aid of oxygen, carbonic acid, or other reacting substances.

This point established, it becomes apparent that the rusting of iron is primarily due, *not to attack by oxygen, but by hydrogen ions.* Absolute confirmation of this view will be given later on.

All substances in solution which contain hydrogen ions, such as acids, stimulate the corrosion of iron. This is also true of salts of strong acids and weak bases, which, though perfectly stable in a dry condition, hydrolyze in solution to an acid reaction; or which, though neutral in fresh solutions, undergo slow decomposition under the action of light, with the formation of acid salts or free acid. With certain exceptions, salts which are perfectly neutral in solution do not prevent oxidation but appear to aid it by increasing the electrolytic action. All substances which develop hydroxyl ions in solution, such as the alkalis or salts of strong bases with weak acids, to a certain extent inhibit, and, if the concentration is high enough, absolutely prohibit the rusting of iron.

Under the electrolytic theory the explanation of the protection afforded by hydroxyl ions is a simple one. Owing to the small dissociation of water, hydrogen ions can not exist in a solution in which the hydroxyl ions are in excess. As hydrogen ions can not exist or be locally formed in sufficiently strong alkaline solutions, no attack is made upon the iron, which remains permanently unaltered. If, however, the concentration of the hydroxyl ions is not sufficiently great, electrolysis can go on with an apparent stimulation of the pitting effects similar to that produced by perfectly neutral electrolytes, such as sodium chloride.

It is known that solutions of chromic acid and potassium bichromate inhibit the rusting of iron. In order to determine the concentration necessary to produce complete protection, a number of polished strips of two different samples of steel were immersed in bichromate solutions of increasing concentration, contained in tubes which were left quite open to the air. There were twelve tubes in each series, ranging by regular dilutions from tenth-normal down to ten-thousandth normal. At the end of two months the last four tubes showed graded rusting with accumulation of ferric hydroxide. No rusting had occurred in any of the solutions above tube No. 8, which contained six-hundred-and-fortieth normal bichromate, a strength corresponding to about 8 parts of the salt in 100,000 parts of water, or about 2 pounds to 3,000 gallons. Since solutions of bichromate do not hydrolyze with an alkaline reaction, but on the contrary are usually slightly acid, some other explanation must be found for this remarkable phenomenon. On first thought it would seem a paradox that a strong oxidizing agent should have the effect of preventing the oxidation of iron, and yet this is precisely the case. If, however, the initial cause of rusting is the hydrogen ion, it is possible to believe that under certain conditions oxygen would prove the most effective of all inhibitors. Dunstan, Jowett, and Goulding have claimed that this peculiar action of chromic acid and its salts is due to the fact that they destroy hydrogen peroxide. This explanation is not satisfactory, and it is fair to inquire whether the electrolytic theory is capable of furnishing a solution of the problem. Furthermore, it will be shown that additional evidence can be brought forward which can not be made to apply to any other theory.

The writer has observed that if a rod or strip of bright iron or steel is immersed for a few hours in a strong (5 to 10 per cent) solution of potassium bichromate, and is then removed and thoroughly washed, a certain change has beeen produced on the surface of the metal. The surface may be thoroughly washed and wiped with a clean cloth without disturbing this new surface condition. No visible change has been effected, for the polished surfaces examined under the microscope appear to be untouched. If, however, the polished strips are immersed in water it will be found that rusting is inhibited. An ordinary untreated polished specimen of steel will show rusting in a few minutes when immersed in the ordinary distilled water of the laboratory. Chromated specimens will stand immersion for varying lengths of time before rust appears. In some cases it is a matter of hours, in others of days or even weeks before the inhibiting effect is overcome.

The passivity which iron has acquired can be much more strikingly shown, however, than by the rusting effect produced by air and water. If a piece of polished steel is dipped into a 1 per cent solution of copper sulphate, a 10-second immersion is sufficient to plate it with a distinctly visible coating of copper which can not be wiped off. A similar polished strip of steel which has been soaked over night in a concentrated solution of bichromate and subsequently well washed and wiped will stand from six to ten 10-second immersions in 1 per cent copper sulphate before a permanent coating of copper is deposited. Even a momentary plunging of the metal into the bichromate will induce a certain passivity, but the maximum effect appears to require a more prolonged contact with the solution.

The first explanation of this phenomenon which naturally presents itself is that a thin film of either oxide or chromate has been formed on the surface of the metal. It is almost inconceivable, however, if such a film is formed, that it can not be seen with the aid of a microscope. There is evidence which appears to indicate that no such film of oxide is formed. It is easy to cover polished iron with a visible film of oxide by simply flaming it gently in a Bunsen burner. Such films do not succeed in protecting the iron either from the rusting or the copper sulphate test. Still more convincing than this is the fact that if a polished surface which has been rendered passive by immersion in bichromate is heated to 100 degrees C. (212 degrees F.) for some hours, its passivity disappears and it again behaves in a normal manner. None of the oxides or chromates of iron are in any sense volatile compounds, so that if a solid but invisible film is really formed, it is in some manner dissipated by heat. Further than this, a chromated strip of iron which is kept in a vacuum soon loses its passivity, whereas a similar strip kept under ordinary conditions remains passive for long periods.

The passivity of iron was discovered by Keir in 1790. Since the phenomenon is produced only by strong oxidizing agents or by galvanic contact when oxygen can separate on the iron, it was explained by Faraday, Wiederman, and others as due to a thin oxide film. From the evidence given above, however, it seems that the passivity of iron is better explained as a polarization effect produced by the separation and retention of oxygen on the surface of the metal. If the rusting of iron is due primarily to the action of hydrogen ions, iron in the condition of an oxygen electrode should be more or less well protected from electrolytic attack.

Keir observed that polished iron which had been immersed in red fuming nitric acid was altered in some manner so that its power of precipitating silver and copper from their solutions was inhibited, and this occurred, in the discoverer's own words, "without the least diminution of metallic splendor or change of color." In the writer's experience red fuming nitric acid does not produce the passive condition as successfully as solutions of chromic acid and its salts. Mugdan discussed the passivity acquired by iron which was immersed in fuming nitric or sulphuric acid and concluded that it was not due to the formation of an oxide film, but was a true passivity in the sense of an ennobling (Veredlung) of the metal, accompanied by a low electrical potential.

Moody asserts that potassium bichromate prevents the formation of rust, owing to the fact that it slowly dissolves iron and its hydroxides. He observed that the addition of ammonia to solutions of chromic acid and its salts which had been allowed to act on iron produced precipitates of hydroxide. This point has been carefully investigated by the writer, with the following results: Iron which is free from manganese is not attacked by solutions of bichromate, even if boiled for days in a flask fitted with a return condenser. Manganese is, however, readily soluble in bichromate solutions, and therefore iron rich in manganese yields a sufficient amount to the solvent action to produce a small amount of brownish manganese hydroxide when the bichromate solution is poured off, made slightly ammoniacal, and allowed to stand. If metallic manganese is boiled in bichromate solutions it dissolves readily, and subsequent addition of ammonia produces an abundant precipitate of brown manganese hydroxide.

If polished iron is allowed to stand for some time in standard tenth-normal potassium bichromate solution, the oxidizing strength of the latter as measured by its titration value is slightly reduced without the

* Abstracted from a Bulletin on "The Corrosion of Iron," issued by the office of Public Roads, United States Department of Agriculture.

solution of the iron or the production of any visible effect. Under the same conditions a standard solution of neutral potassium chromate is slightly reduced with the appearance of a small amount of chromic hydroxide. In fact, all the evidence obtainable points to the abstraction by the iron of some of the available oxygen of chromic acid and its salts without the formation or solution of iron oxide films.

In order to show beyond doubt that an oxygen electrode is formed by immersing iron in a strong solution of bichromate the following experiment was made: Two polished steel electrodes were prepared and chromated by immersion for a number of hours in a strong solution of potassium bichromate. The prepared electrodes were then thrust tightly through a rubber stopper, closing a Jena flask, which was then filled with pure freshly boiled distilled water. The electrodes were then attached to the poles of a primary battery at about 2 volts potential. At the end of half an hour, although the potential was not sufficient to disengage bubbles of gas and no visible change had occurred, the electrode which was connected to the zinc pole of the battery had lost its passivity, the other retaining it.

It might still be objected that if a film of oxide had been formed it might suffer reduction at the negative pole. It is, however, very easily shown that electrodes which have been oxidized by gentle heating are not reduced under the conditions of this experiment.

Wood in 1895 commented on the power of paints and pigments containing certain oxidizing agents, notably potassium bichromate and lead chromate, to form on iron and steel surfaces a thin coating of oxide which so effectually protects the metallic surfaces from corrosion that after the removal of the paint the metal still resists atmospheric effects for a long time, as well as the stronger effect of immersion in sea water or acidulated waters and sulphurous and other vapors. This action, Wood adds, is very obscure and not thoroughly understood; but the fact remains, and extended experiments in this field only demonstrate its presence and usefulness.

The oxide film theory has been held for many years to account for the passivity of iron, but in the writer's opinion the protection afforded by certain oxidizing agents is electro-chemical and not mechanical. Perhaps the most conclusive proof that electrolytic action must take place before rusting can occur is given by an experiment of Moody's, which has been repeated and confirmed by the writer. Dunstan and his co-workers claimed that when iron is placed in hydrogen peroxide the metal is rapidly oxidized, with formation of ferric hydroxide. As Moody has pointed out, commercial hydrogen peroxide is invariably acid and contains impurities. In perfectly pure hydrogen peroxide bright iron will catalytically disengage oxygen and retain its polished surface unacted upon. It is not an easy matter to prepare a perfectly neutral pure solution of hydrogen peroxide, but it can be accomplished by two fractional distillations at 85 degrees C. (185 degrees F.) under reduced pressure (700 millimeters) of commercial dioxygen. Before distilling the second time the solution should be made barely alkaline with a few drops of one-hundredth normal potassium hydroxide. In a pure neutral one per cent solution of hydrogen peroxide thus prepared, Moody's observation was confirmed. Iron immersed in the solution remained bright for a protracted period. Hydrogen ions do not exist in a pure neutral solution of peroxide; therefore neither solution of iron nor electrolysis can take place. If the flask containing the specimens covered by pure hydrogen peroxide solution is connected to a vacuum pump, oxygen is disengaged freely and boils off the metal without the slightest appearance of rust.

Reduced to its simplest terms, the following explanation of the rusting and corrosion of iron seems to the writer the only one that is tenable. In order that rust should be formed iron must go into solution and hydrogen must be given off in the presence of oxygen or certain oxidizing agents. This presumes electrolytic action, as every iron ion that appears at a certain spot demands the disappearance of a hydrogen ion at another, with a consequent formation of gaseous hydrogen. The gaseous hydrogen is rarely visible in the process of rusting, owing to the rather high solubility and great diffusive power of this element. Substances which increase the concentration of hydrogen ions, such as acids and acid salts, stimulate corrosion, while substances which increase the concentration of hydroxyl ions inhibit it. Chromic acid and its salts inhibit corrosion by producing a polarizing or dampening effect which prevents the solution of iron and the separation of hydrogen.

(To be continued.)

INCANDESCENT ILLUMINANTS.*

PROGRESS IN MANTLES.

BY JAMES SWINBURNE, F.R.S., ETC.

A little more than twenty years ago, Auer von Welsbach, who was engaged on researches on the rare earths, invented the modern incandescent mantle. His first mantles were made of zirconia and yttrite earth, in the proportion to make a normal zirconate. Shortly afterward, he found that the best material has a basis of thoria. Pure thoria, which requires care in its preparation, gives very little light, but if a small percentage of a colored and permanent oxide, such as ceria, is added, it gives good illumination.

There has been much discussion about the theory of the incandescent mantle. It has been generally assumed that the temperature of a Bunsen burner is too low for a mantle to give the light it does by simple radiation, unless it is much hotter than the flame. Unfortunately, the temperature of the flame is generally taken with a thermo-couple, and this gives far too low a reading, as the thermo-couple never reaches the real temperature of the flame. But, admitting that the temperature of the flame is high, it is still urged that the light given by the thoria with a small percentage of ceria is so great that there is something else than mere thermal radiation. It is said that the ceria acts as a catalytic agent, and that it oscillates between two states of oxidation. Ceria does act in somewhat the same way as platinum; for instance, if a ceria mantle is put on a lighted burner, and the burner turned out, and the gas turned on again, the ceria mantle will glow and will finally light the gas. It is odd that this is not brought forward by the advocates of the catalysis theory; but the opponents might urge that zirconia will do the same thing, and the zirconia mantle gives very little light. This does not really dispose of the catalytic theory.

According to the simple radiation theory, the light depends only on the emissivity, or blackness of the mantle, and its temperature. Its temperature must be lower than the flame, as it must be robbing the flame of the heat it radiates. In order to give the flame every chance of supplying the heat, the threads of the mantle have to be made very fine, so that the flame can rush through the meshes, and the hot gas should be in brisk movement through the interstices of the mantle. By using a special draft arrangement, known as the intensive system, about twice the light per cubic foot of gas can be obtained. In order to get the highest temperature the emissivity should be low, that is to say, the mantle should be very white: but then, though it would get to a high temperature, it would give very little light. On increasing the emissivity the light will first increase, but this means a lower temperature, so that as the emissivity is increased from white to black, the total radiation increases, but as that means a greater abstraction of heat from the flame, the mantle is cooler, and therefore radiates a larger proportion of the energy as heat and a smaller proportion as light, so the mantle gets redder and gives less light. This is just what happens in practice, whether ceria or any other colored oxide is used.

It has been urged that as pure ceria is white, adding it cannot make the mantle blacker; but ceria is white only when cold. A mantle may look quite white cold, and be darker in color when hot. Rubens has devised an experiment to show this. The mantle is strongly illuminated by an arc and condenser, and its image is thrown on the screen. It looks quite white, of course. On lighting the gas, the mantle, instead of becoming still brighter, at once becomes dull. Again, alumina, which is white, gives little light. Chromium oxide is so dark that it gives only a dull red glow. But on adding a little chromium oxide to the alumina, a dark red light is first given, because the chromium oxide is too dark; but as soon as it combines with the alumina to make a light pink mantle, a good light is obtained.

The incandescent mantle is now applied not only to the ordinary Bunsen burner, but to an inverted form, which lends itself to decoration, and to the petroleum lamp. It is now also applied to air carrying a little hydrocarbon gas, and this application is said to provide an extraordinarily cheap light, which is especially useful for country houses.

One of the drawbacks of gas, compared with electric lighting, is that merely turning on does not light gas. This difficulty has been largely overcome by the use of the by-pass, but further advances have been made. Welsbach has discovered that an alloy of cerium and iron gives off sparks on being scraped or filed, and a burner has been designed in which the act of turning on the gas scrapes a little wheel of this alloy, causing a spark, which lights the gas. This overcomes the drawback of having a little jet always burning. Another invention allows the gas to be lighted from a main tap. Each burner has an attachment, which lets the gas straight through to the burner when the pressure is on; but on turning the main supply off, and allowing a little gas to pass at the controlling tap, the attachment to each burner turns off the burner and lights a little pilot jet, which keeps alight until the light is wanted again. On turning on the main tap, the pilot jets light the various burners and go out themselves. By this means burners can be fully lighted up by turning one tap at the door of the room.

The electric incandescent light is undergoing a great change. Carbon is being replaced by metal wires. It has been found possible to make wires of high enough resistance of tungsten, osmium, tantalum, and a few other metals and compounds. The osmium lamp was the first of these, but there was difficulty in making it of high enough resistance. The tantalum lamp is now in great demand. It is made for 100 to 130 volts, and is much more efficient than the carbon lamp. It will not last long on alternating currents, however. The wires of a lamp that have been run for some time on a direct current show a curious notched or crinkled appearance under the microscope. But a wire that has been run on an alternating circuit looks as if the metal had been melted into short cylinders with round ends, and these cylinders had stuck together end to end without their centers being in a line. Sometimes the little cylinders are nearly separated, merely touching at a corner. This action is very extraordinary, and has never been explained. In addition to this, when a lamp breaks down on an alternating circuit, the wire sometimes goes at one point, and sometimes it breaks in several places, and tangles itself up in an extraordinary way; at other times it breaks up into numerous little pieces, which will be found lying on the inside of the globe. Some of the other lamps show a change under the action of the current, but it is not so marked as in the case of tantalum.

One of the most interesting of the new lamps is the zircon. It is said to be made of zirconium and tungsten, and lamps of this material have been made for 200 volts, a matter of the greatest importance from a distribution point of view. It is possible that the conductor is really a zirconide of tungsten, and this opens up a new series of compounds. A zircon lamp for 100 volts has really six separate loops of wire mounted in series inside a bulb. A recent improvement is to provide an extremely light spring for each loop, so as to keep it taut. The lamp can then be used in any position.

Tungsten seems to be the favorite metal, as it gives a very high efficiency. It is probable the lamp of the future will have an efficiency of nearly a candle per watt, and this is promised by the use of tungsten. At the same time it must be admitted that to make a wire with a resistance of 500 ohms small enough to give 20 candles with 20 watts is a triumph of inventive skill.

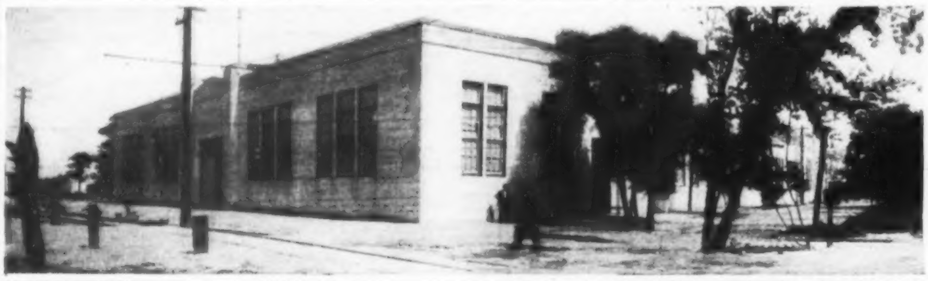
* Abstract of a discourse delivered at the Royal Institution April 26, 1907.

The adaptations of plants growing in arid regions, for accumulating and holding a reserve supply of water, have been described by Dr. MacDougal, in the "Fifth Year Book of the Carnegie Institution of Washington." Special storage organs and storage plants are most abundant in regions in which the scanty rainfall occurs during a brief period only, while during the remainder of the year precipitation is comparatively lacking. The development of tissues for storage purposes is varied, and shows some important morphological features. *Ibervillea sonoræ*, one of the cucumber family, produces a storage organ the size of a squash, at the base of the stem, which is covered with a skin highly resistant to evaporation. During the dry season these structures lie unchanged on the hot sand. At the commencement of the rainy season, roots and shoots are quickly formed, and the fruit and seed matured, when the thin stems die down and the organ rests for another season. Some of these storage organs were collected and placed on a dry shelf in a museum, in 1902, where they have since remained. Every year since, at a period corresponding to the rainy season in its native habitat, thin stems are produced, which eventually die back. Five years' growth has already been made at the expense of water stored up in 1901, and the storage organs are still sound and will probably furnish supplies for the annual production of stems and leaves for some years to come.

THE FUEL-TESTING PLANT OF THE UNITED STATES GEOLOGICAL SURVEY AT THE JAMESTOWN EXPOSITION.

BY C. T. WILKINSON.

The fuel-testing work of the United States Geological Survey should be followed with close interest by all engineers, for it is important to all power consumers, being undertaken to point out new paths for the development of the natural resources of the country by locating, classifying, and testing all kinds of available fuel.



THE POWER AND ALCOHOL BUILDING AT THE JAMESTOWN EXPOSITION.

A report of the more recent results of this branch of the Survey's work will soon be published, and the following particulars of the plant in Virginia will meanwhile be of interest.

In the steam engineering division new apparatus has been added as follows: A 250-horse-power Babcock & Wilcox boiler, with superheater, provided with a Roney stoker; a Jones underfeed stoker with fan, added to one of the old Heine boilers; two direct-current De Laval turbine sets rated 300 horse-power at about 9,000 revolutions; also three Green Fuel Economizer Company's induced-draft fans.

The method of work planned for this section is to be slightly changed, so that instead of testing a great variety of coal, more tests will be made of the same coal, different sizes and different methods of stoking or feeding, etc., being employed with the object of determining the most economical performance under different rates of combustion and the best ratios of grate and heating surfaces.

The B. & W. boiler will be placed beside the two Heine boilers, which have been brought from St. Louis, all three having been provided with induced-draft apparatus in order to get a wide range of capacity. The Heine boiler provided with the Jones stoker has the usual arrangement for forced draft. The B. & W. boiler was inserted partly to enable tests to be made of the same fuel with different types of boilers. It serves to represent the types employing the perpendicular flow of the gases through the tubes, the parallel-flow types being represented by the Heine boilers. The Heine boilers have been rebaffled or partitioned in such manner as to practically double their length by compelling all the heated gases to pass along the entire length of the tubes twice.

An additional alternating-current turbo-generator set may be installed, to supply power for external and exhibition purposes.

The steam engineering division, which has now practically succeeded in isolating the performance of the boiler from that of the combined performance of the boiler and furnace, will continue tests with the object of still further determining the performance and efficiency of the furnace alone.

The apparatus in the producer-gas section is arranged as shown in an illustration. The producer gas, immediately on entering the building, passes through the meter and thence to the Westinghouse gas engine transferred from the St. Louis plant. Some slight changes have been made in this apparatus. For instance, producer No. 7 has been provided with a water seal at the base to permit the ashes to be removed without admitting air, and several holes have been bored at different heights, to be used for extracting samples of the gas. The purifying apparatus used at St. Louis has been removed, since experience indicates that the danger from impurities has been considerably exaggerated.

A special steam pipe has been provided to insure a steady water pressure, since the pressure of the supply mains fluctuates considerably.

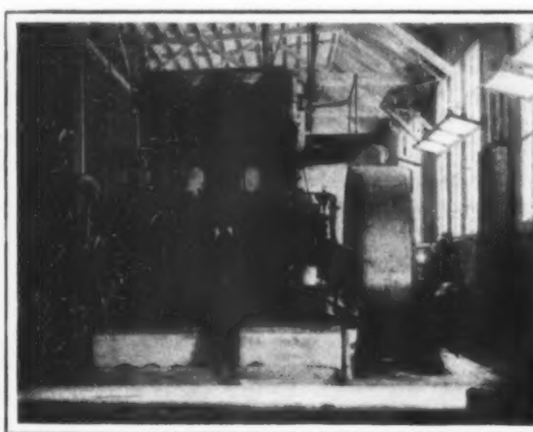
The gas engine is belted to a 200-kilowatt Bullock generator brought from St. Louis, which serves to drive the motors for the apparatus in the building, the machine shop, the briquetting plant, the elevators, and the conveyor. Any additional load required is obtained by means of a water-box resistance, which can be regulated by the switchboard attendant, so as to maintain a steady full-load value.

The plans of this section include the following determinations:

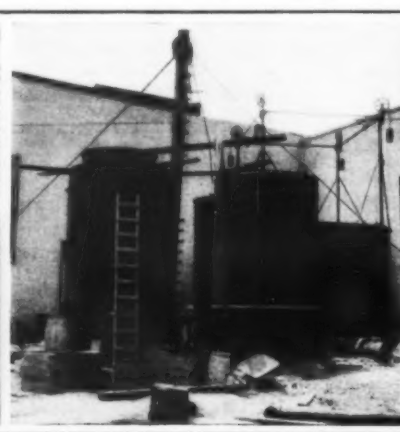
The proper length for a test run, the effect of the size of the coal, the best depth of the fuel bed, the effects of rapid load variations, the maximum returns from different fuels, and the response of a producer plant to sudden demands for power.

In the alcohol and gasoline engines section a new work of great importance is being undertaken. Its equipment includes two 15-horse-power, 250 R. P. M. Otto gas engines; two 15-horse-power Nash Company's engines; one 2-horse-power International Harvester Company's engine; and two John Deem engines rated at 14 and 18 horse-power respectively.

Experiments will be made covering the whole range of this field, but for the present the work will be confined chiefly to examinations of different carbureters, with the object of showing the lines along which a more efficient method of vaporization may be obtained. Other prominent work is the examination of the kinds of fuels available, with special reference to gasoline *versus* alcohol, and an investigation of the use of



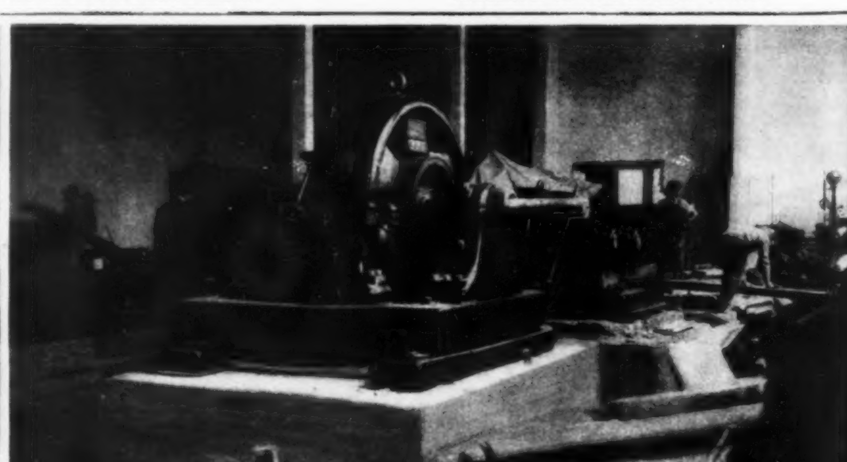
THE 235 HORSE-POWER WESTINGHOUSE GAS ENGINE.



THE GAS-PRODUCER PLANT.

INTERIOR OF THE BOILER HOUSE.

A DIRECT CURRENT DE LAVAL TURBO-GENERATOR SET.



THE BULLOCK GENERATOR.

FUEL-TESTING PLANT OF THE UNITED STATES GEOLOGICAL SURVEY AT THE JAMESTOWN EXPOSITION.

kerosene as fuel for this class of engines—an investigation necessitated by the increasing demand of gasoline and the limited supply available.

The study of the destructive distillation of coal and its combustion in gas producers, coke ovens, and furnaces, especially from the standpoint of physical chemistry, will be undertaken by several divisions.

The briquetting division, which occupies the large room at the end of the building, is putting down one large additional German briquetting machine, while the previous apparatus of English and American manufacture that was used at St. Louis is installed in the same room. The work of this division will be chiefly the manufacture of briquettes from various run-of-mine coals of the Eastern fields, which will be tested on war vessels under the direction of the steam engineering division. The further plans of the Geological Survey include tests dealing with the spontaneous combustion of stored coals, in which an effort will be made to simplify the methods for its prevention, while a corps of specialists will be detailed to investigate closely the whole subject of explosions in coal mines, with a view to eliminating danger from this source.

NEW DEVELOPMENTS IN ARC LAMPS AND HIGH-EFFICIENCY ELECTRODES.*

A COMPARISON BETWEEN METALLIC AND CARBON ARCS.

BY GEORGE M. LITTLE.

Arcs for lighting may be formed between electrodes of many different kinds. This paper deals with the development of the so-called magnetite electrodes and of a lamp suitable for burning them. A few points of comparison between these metallic-oxide electrodes and carbon electrodes will be considered, and some of the many interesting advantages possessed by the metallic-oxide electrodes and lamp will be touched

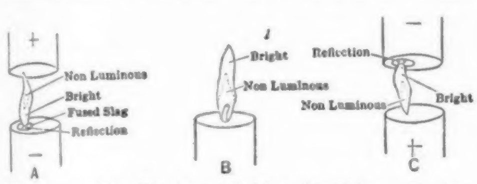


Fig. 1.—A. Metallic Arc with Negative Below. B. Candle Flame. C. Metallic Arc with Negative Above.

on. Among these are the long life, high efficiency, and good distribution and color of light.

The magnetite electrodes were so named because magnetite is usually one of the constituents of the negative or cathode, but it would be more satisfactory to call them metallic-oxide electrodes, as, in addition to the magnetite, there are always at least two other oxides present, namely, oxide of titanium and oxide of chromium.

These electrodes are made in a very different manner from the carbon electrodes. As is well known, the latter are squirted or molded from a plastic mixture and are baked, the carbon furnishing sufficient mechanical strength and electrical conductivity. A metallic-oxide electrode cannot be made this way, for it is a familiar fact that a fine powder is a poor conductor, no matter of what it is composed, and as these electrodes are made for the most part from finely powdered oxides, it is evident that a conducting binder or a conducting case would have to be used. In practice, the mixture of oxides is tamped into a thin iron tube and the end sealed in an arc.

The oxides have distinct and separate reasons for their presence. The titanium oxide has the property of rendering the arc luminous; and it may be here noted that the metallic-oxide arc is a flame arc, the light not coming from a crater as with carbons. The oxide of iron gives conductivity to the fused mixture when cold, the other oxides being conductors only when hot. The oxide of chromium prevents a too-rapid consumption, so that by its use an electrode may be given a very long life.

The positive, or anode, used with these metallic-oxide negatives is generally a metal and is consumed much more slowly than the negative. This is con-

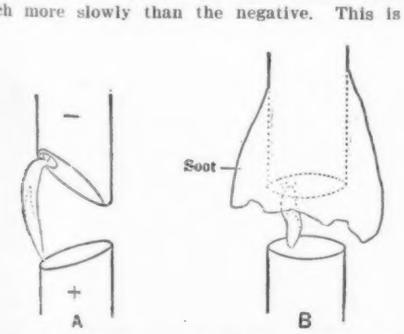


Fig. 2.—A. Showing How the Ends of Carbons Wasted Away to a Bevel Before Using the Down Draft of Air. B. Showing Accumulation of Sponge-like Masses of Soot Before Using the Down-Draft of Air.

trary to what would be expected, judging by the action of carbon electrodes.

There are a number of advantages possessed by the metallic arc over the carbon arc. In the first place, the efficiency is much better; that is, a metallic arc lamp operating on a four-ampere current with approximately 65 to 70 volts at the arc will give a light equal or superior to that of a 6.6-ampere, 75-volt, direct-current, inclosed-carbon arc lamp.

The distribution of light is far better. This is owing to the fact that in the inclosed-carbon arc practically all the light comes from the crater on the flat under-surface of the upper electrode, most of it being thrown down and not serving to illuminate the street between lamps. The light from the carbon arc itself is weak and of a blue color. This is very pronounced at times, especially if the flat under-surface of the upper electrode is somewhat inclined, thus hiding the crater. In the case of the metallic-oxide electrodes, the arc is itself the source of light, practically none coming from the crater, except by reflection. The metallic arc is much like a candle flame, having its luminous and non-luminous zones. The light is brightest near that end of the arc which is next to the negative electrode, and comes from a hollow cone-shaped mantle of volatilized oxide of titanium rendered incandescent by the heat of the arc, just as in the candle flame the light comes from a hollow cone-shaped mantle of carbon particles made white hot by the heat of the flame.

The voltage required to maintain a metallic arc is less than that of an inclosed-carbon arc. It is a familiar fact that an inclosed-carbon lamp will not burn properly with the arc voltage down to 65, while a metallic arc will burn well at less than 55. Metallic arcs are adjusted to burn at from 65 volts to 75 volts in different cases, while the carbon arcs are all set

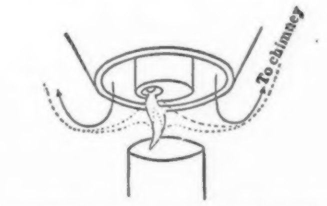


Fig. 3.—The Down-Draft of Air Forces the Soot to Take the Path Shown by the Dotted Line, Effectually Keeping It from Touching or Depositing on Anything.

at 80. This is a very evident advantage in favor of the metallic arc, as more lamps may be put on a circuit without raising the voltage on the line.

The life of carbon electrodes, as a rule, is not over 150 hours, while the metallic-oxide electrodes can go considerably longer.

The uniform white color of the metallic arc is in marked contrast to the changeable blue and white of the inclosed-carbon arc.

As the metallic-oxide electrodes are not burned "inclosed," there is no inner globe required on the lamp.

While it looked easy to secure all of these advantages, many difficulties appeared, but they have now practically all been overcome. In the first experiments the electrodes were trimmed with the anode or positive above and the negative or metallic-oxide electrode below, just as carbon lamps are trimmed, but a number of troubles presented themselves.

First—The bright portion of the arc was near the surface of the lower electrode, which cast a large shadow.

Second—The light reflected from the brilliant surface of the fused slag on the lower electrode was thrown upward and could only be partly saved by using a reflector.

Third—An under-feed mechanism was seen to be necessary, as, contrary to the action of carbon electrodes, the negative metallic-oxide electrode is the more rapidly consumed.

Fourth—Only a comparatively short metallic-oxide electrode could be used, as a long one would necessitate the use of an unwieldy long glass globe. This would limit the life and could only be met by adopting a negative electrode of large diameter, which it is evident would be undesirable.

Fifth—A particularly undesirable feature was the gathering of a large amount of reddish soot that would collect in spongy masses around the electrodes, obscuring the light. This had to be removed by some mechanical means, such as scraping or shaking it off, and some receptacle other than the glass globe had to be provided to catch it.

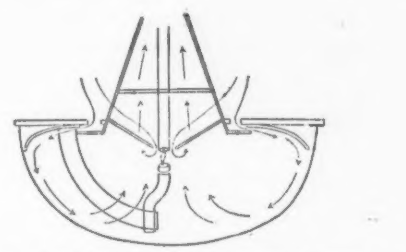


Fig. 4.—Path Taken by Air Currents in Lamp.

Sixth—The negative or metallic electrode was seen to burn to a blunt taper point, causing the arc to be very unsteady, as it tended to leave the end and run up the side in the manner of the carbon arc when flaming.

As noted above, the bright portion of the metallic arc is located near the surface of the negative electrode, and it was seen to be very desirable to burn the electrodes with the negative above, thus getting the bright portion of the arc in such a position that the shadow thrown down would be less, and that the light reflected from the brilliant surface of the fused pool of slag on the negative electrode would be thrown down and utilized instead of being thrown upward and wasted. The other advantages, noted above, possessed by the carbon lamp would be retained if this inverted position of the electrodes could be made practical.

The first attempt to burn the metallic-oxide electrode above and the metallic electrode below showed that there were serious obstacles to be overcome before it could become a practical method. In the first place, the electrode would not keep a square end, but would waste away on one side, and the arc would run up this bevel, or slope, giving a very unsteady light. In the second place, the volatilized oxides of iron, chromium, titanium, and so forth would condense on the sides of the electrodes and hang down as a fringe or curtain, hiding the light.

The first means taken to overcome these troubles was the introduction of a rotating draft of air around the arc. This had the effect of forcing the arc to hold to a central position, stopped the crooked burning, and steadied the light, but did not take care of the fumes. Attempts to blow the fumes away sidewise gave only partial success. Finally, a current of air was directed down around the arc, and this gave excellent results. The electrode burned perfectly

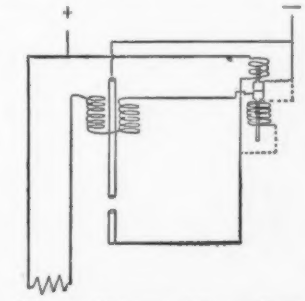


Fig. 5.—Diagram of Connections.

square, and the clean layer of air prevented any gathering of fumes. This was a very marked advance, as this did away with any need for a mechanical scraper or shaker, the soot practically all passing out of the chimney and not requiring to be caught in any receptacle, the globe remaining clean.

When burning metallic-oxide electrodes with the metallic-oxide stick below, copper was used as an anode with fair results. On reversing the position of the

* A paper read before the National Electric Light Association.

electrodes, it was found that the new conditions made it possible to improve on the action of a pure copper anode, and a number of changes were accordingly made. In the first place, if the arc plays for a time on pure copper, it will oxidize the surface. This oxide will fuse to a slag that becomes an insulator when cold, and on starting a cold lamp it is necessary to strike the electrodes together hard enough to break through the slag. To strike such a hard blow is undesirable, as if it is done while the lamp is burning—for example, when feeding—it is liable to spatter the fused slag out onto the glass globe. A simple remedy for this consisted in using an anode containing metals or alloys whose oxides, when fused together, would make a slag that is a good conductor when cold. The steadiness of the light largely depends on the composition of the slag, its uniformity and temperature. The anode surface is at all times covered with this slag, which slowly dissolves the metal and is itself slowly volatilized. If the arc plays on bare metal it consumes it rapidly, and it was found desirable to secure this slag cover from being knocked off. This was accomplished by providing a rough surface for it to cling to, and by running the entire anode tip very hot.

A characteristic property of the metallic arc has been a very noticeable dying-down or dimming of the light, which would occur at irregular intervals, especially after the electrodes had burned for twenty hours or more. These dim spells would last from a few seconds to two or three minutes, when the normal brilliancy would return. This is explained as follows: In the metallic arc, the brilliancy is largely due to the presence of volatilized oxide of titanium, and anything that interferes with the uniform evolution of vapors of titanium will cause the light to dim—for example, the presence of a high percentage of highly fusible oxide of chromium. This oxide of chromium is volatilized at a slower rate than the oxides of titanium and iron, and after the electrode has been burning some twenty hours the slag on the end of the cathode has become very rich in oxide of chromium, which forms a film on the surface of the fused pool of oxides. When the film is not present there is a plentiful evolution of oxides of iron and titanium, and there is a bright arc. The oxide of chromium can be seen to gather on and finally entirely cover the surface of the pool. This stops the evaporation of titanium and iron, and the light burns to a bluish color and dies down until the chromium film is burned away again. This trouble was met by modifying the mixture in such a way that the oxide of chromium could not separate from the oxides of iron and titanium, thus doing away with the film on the surface and entirely doing away with the dim spells.

In carbon lamps there was very little done to keep the impurities volatilized from the carbons from depositing on the globe. This trouble had to be met by the carbon manufacturers, who were prodded up to produce carbons containing less than 0.2 per cent of impurities, but this means was not to be considered in the case of the metallic-arc lamp. The metallic-arc electrodes, being chiefly composed of oxides of iron, titanium, and chromium, do not burn away to an invisible gas, as does a carbon stick, but are volatilized bodily, and the vapors instantly condense, on leaving the arc, to a fluffy reddish soot that settles on everything it touches, so that a chimney is a very necessary feature in the lamp. This soot, if it comes in contact with the reflector or globe, will smudge them badly in ten minutes. As was noted before, a current of air flowing down around the electrode served admirably to keep it clean, so it was applied to the reflector and globe with gratifying results. A thin layer of air is introduced at the top of the reflector and forms a shield through which the soot-laden air cannot penetrate, so that the reflector and globe will keep clean for a long time.

As the air currents play such an important part in this lamp, it became necessary to do a large amount of experimental work on the design of an air intake and of a chimney top. The chimney could not be made long enough to cause a very powerful draft, so the wind was very apt to blow down it; but by persistent effort the openings have been so designed that the wind may blow from any direction (up, down, or sidewise), and the only effect is to increase the natural draft in the lamp. Incidentally, the increasing of this draft actually centers the arc and holds it quiet.

It was found advisable to run the lamp at 4 amperes and 65 to 68 volts at the arc with a cut-out set at 85. This low cut-out was made possible by the inverted position of the electrodes and by the peculiar arrangement of the air draft, which prevented any tendency of the arc to flame or to run up the side of the electrode. Without these features, a cut-out of 100 to 110 volts would be necessary. As the power-factor at which the lamps operate depends largely on the amount of variation of voltage in the arc, this 85-volt cut-out is seen to be very desirable. In actual service the lamps, including a mercury arc rectifier, run very well at from 65 to 70 per cent power-factor.

In several places above we have described special conditions that must be obtained for getting the best results with these electrodes, and these conditions, of course, must be supplied by the lamp in which they are burned. An example of a lamp well adapted for this service is here shown. A study of its design and construction will show that it is simple and rugged, as no float feed is used; it being necessary only to strike an arc and hold the electrode in a permanent position until, due to change in voltage, the cut-out causes the restriking of the arc. The lamp consists essentially of a base and top, connected by a chimney, a set of magnets for striking the arc, a shunt cut-out for causing the lamp to feed due to rise in voltage, and a series cut-out for disconnecting the striking magnets after the arc has been formed.

The special conditions described with regard to drafts are obtained, as seen here, by the down-draft tube, which directs the current of air down around the electrode, another current of air over the reflector and circling around the globe forming a means of protection to them, and a special construction of top and case for giving proper draft conditions when under all conditions of wind.

THE GRADUAL ADVANCE OF SCIENCE.

THE RISE OF CHEMISTRY AND PHYSICS.

BY PROF. CHARLES BASKERVILLE.

Among the Greek philosophers, of whom Aristotle was a leader, there prevailed the opinion that a body could be hot or cold, wet or dry. A body could not be hot and cold or wet and dry at the same time. It may, however, be hot and dry (fire), hot and wet (air), cold and dry (earth), or cold and wet (water). Earth, air, fire, and water constituted the four elements of the Greeks.

The Arabs, who contributed enormously to our knowledge of chemistry, made the first systematic effort to explain the observed diversities in matter by the nature of the constituents of which it is composed. But for many centuries the development of chemistry was but an incident in the history of alchemy, or the "black art," as it was sometimes designated. The genuine alchemist sought to transmute base metals into gold.

In the eighth century the Arabian alchemist Geber (Abou-Moussah-Dschafer-al-Sofi being his full name), a true worker in seeking "perfection," considered all metals as compounds of mercury and sulphur. A metal was supposed to exhibit the sum of the properties of its constituents. The mercury or quicksilver was the vehicle of the qualities of ductility, fusibility, and luster, while the sulphur or brimstone offered the quality of combustibility. The differences between the individual metals, like gold, silver, and copper, were said to be due to the relative quantities of these constituents and to the degree of purity exhibited by them. The accomplishment of the highest purity was the "perfection" sought, but never reached, by Geber.

Five hundred years later Roger Bacon, the great philosophic alchemist, the reputed, and at least an independent discoverer of gunpowder, maintained that it was as absurd to wish to transform lead into silver, copper into gold, as to pretend to make something out of nothing. He insisted that the first necessity was to remove from the rough earthy mineral a bright metallic substance like lead, tin, or copper, as Geber before him maintained. This was only the first step toward "perfection" for Bacon. According to him, the most perfect gold is that found in the native state. It is perfect because in it nature finished her work. Therefore, the alchemist should seek to imitate nature. Nature makes no note of the cycles necessary for her work, so something was needed which would accomplish in a short time that which nature did in ages. The alchemist, therefore, should seek the "philosopher's stone," with a pinch of which it was hoped the vast changes could be made.

If we take a bone and burn it, we get fire, the ash (earth) left behind, water given off, and a gas produced. If that ash be mixed with powdered coal and heated in a retort, as was done by the alchemist Brandt in the seventeenth century, we obtain a yellow substance known as phosphorus. This "light of Satan" was exhibited in all the courts of Europe as a new and remarkable substance because it glowed in the dark and eventually took fire when exposed to dry air, burning with a brilliant light. No other substance was known to possess these qualities, hence it was called an element. Later it was learned that if this yellow, spontaneously inflammable body be heated just below red heat in a close tube with no air present, it acquired a red color, no longer glowed in the dark, or took fire. The former substance is very poisonous, whereas this red variety is harmless. Under proper conditions the red may be changed back into the yellow phosphorus. These facts are related, as they have an important bearing upon that which immediately follows.

During the latter part of the seventeenth century, a German physician of the name of Becher explained the process of combustion as a form of destruction, a dissolution of the combustible substance into its components. According to this, what we now term an element cannot burn. His pupil, Stahl, elaborated the hypothesis by assuming that each combustible substance consists of the product of combustion united with an inflammable principle called "phlogiston"; a metal and this principle of fire combined together. From the observations made, there was good reason for accepting this hypothesis, but as Henry James has said, "we grope in the dark, carrying each our poor little taper of selfish and painful wisdom." Facts are facts, when accurately observed. Explanations are quite different. They constitute merely scaffolding for the structure of science and are to be cast away as soon as they shall have served their purpose.

It remained for Lavoisier, whom the French delight in calling the "father of chemistry," although they executed him during the revolution in the last quarter of the eighteenth century, to weigh the metals before and after the burning. He proved that nothing had been lost—in fact, there was a gain. No phlogiston or burning principle that was weighable had been given out. The principle of the conservation of mass or weight was thus established.

Just a century ago the Englishman John Dalton learned by experiment that a metal, when burned, always gained the same in weight. This he explained by stating that matter consists of very small indivisible particles, called atoms, which possess definite weights. These weights are unchangeable. These atoms, about eighty different kinds being known at present, make up all the various kinds of matter with which we are familiar. They enter in different proportions, but never in less weight than that of the atom, although many atoms may be in a substance. If these atoms are different we have a compound, just as in the bone mentioned we have our phosphorus, calcium, and oxygen. If the atoms be alike, as in our phosphorus, we have an element—an element being a substance which has not yielded anything simpler than itself.

The determination of the weight of an atom is a delicate operation, dependent upon great skill and many matters of technique familiar only to an expert. In studying the figures obtained, Prout noted that many of them approximated whole numbers. The approximation he attributed to defects in the methods or apparatus employed. If perfected, whole numbers would result. For example, oxygen, having an equivalence of 15.9, was really 16. Therefore he maintained that all the elements were actually composed of the smallest. If we could condense sixteen of hydrogen into the space of one, we should have oxygen. In short, for the transmutation of the elements it was only necessary to secure a machine which would do the work. This was in 1815. To test this, the Belgian chemist Stas determined many of the atomic values. This was a monumental labor subsequently equaled only by the classical work of Theodore Richards, of Harvard, who, as exchange professor, lectured this year in the University of Berlin.

One element—chlorine—a constituent of common table salt, always gave a value of about 35.5. In an effort to harmonize these facts a Frenchman, Dumas, said that all elements were made up of half atoms. This did not prove satisfactory, so Zangerle, in an effort to account for all the fractions obtained, said that hydrogen should be subdivided into one thousand parts. These speculations were not substantiated by the facts observed, so they constituted merely an event in the history of chemistry to be revived within the past decade apparently with experimental proof.

Just before our civil war began, two Germans, Bunsen and Kirchhoff, devised the spectroscope. With this instrument a beam of white light may be broken up into a rainbow of colors. If the light be from some element which is burned we get definite bright lines in fixed places. These lines are characteristic for the particular element experimented with. By common consent we regard a substance an element which has

definite atomic weight and spectrum. To prove the existence of a new element it has never been necessary to actually get it isolated, for the atomic weight and spectrum could be had from its compounds. In fact, up to this time no element was known which did not form compounds. Compounds are the result of the mutual attraction of the elementary constituents; therefore, each element possesses an inherent property called chemical affinity, which brings about the union in compounds.

Man has been breathing and walking through air since its existence. We have seen that once he regarded it an element. Work of numerous scientific men showed that it was essentially a mixture of one part of oxygen and four parts of nitrogen by weight. If there were one material phase of nature that men of science thought they understood, it was the air. Yet, in 1894, Lord Rayleigh and Prof. William Ramsay learned that the air contains about 1 per cent of another element—argon. This element is characterized by the absence of that usual property of the elements, namely, the ability to form compounds. So far, chemists have failed in all their efforts to make this argon combine with other bodies. It is remarkable that a man of average weight breathes about a cubic foot of this lazy gas every twenty-four hours, and the man of science, with all his refinements of investigation and research, failed to detect it through the centuries he has busied himself with observing the phenomena of nature around him. This discovery was crowned with the Hodgins prize of $10,000 by the Smithsonian Institution in Washington.

In 1868 Jannson, and later Lockyer, independently noted an unusual line in the spectrum produced by the light given out by the chromosphere or luminous envelope of the sun. This was attributed to a new element, helium. Sir William Ramsay and his assistant, Travers, found this solar element in certain rare minerals on the earth. It is just four times as heavy and next in lightness to hydrogen. It resembles argon in its inactivity, and occurs with three other similar elements in the air, but in extremely minute amounts, so small that the ordinary methods fail absolutely in its detection. For this work Ramsay received the Nobel prize of $40,000.

Ten years ago an intrepid Polish woman and her brilliant Parisian husband, Prof. Curie, announced a discovery that startled a world accustomed to wonders. Radium is even more remarkable to-day than phosphorus was to those seventeenth-century alchemists. It has caused such astonishment that we have so far been unable to coin an adjective sufficiently descriptive. It glows in the dark; it is always hotter than its surroundings; it charges bodies electrically when they are near; it discharges bodies already charged with electricity, and it constantly gives off a gas called an "emanation" by Rutherford, its discoverer. This emanation goes through a number of changes, eventually forming helium.

Radium is an element, according to agreement, for it has a definite atomic weight and a characteristic spectrum. So is helium. Radium is transmuted into helium and we have apparently the dream of Geber realized. This has been the attitude of belief on the part of the most generous contributors to our knowledge of these unique substances. The opposite point of view, however, has been held by Lord Kelvin in England and the writer in this country, because if radium be an element, it should not break up into anything simpler than itself. These opponents have no objection to changing their definition of an element, or even accepting radium as a "temporary element" or "meta-element," a term by which Sir William Crookes designated certain "nebulæ of elemental matter."

Just as this more conservative view is securing a foothold among men of science, we are confronted with the experimental evidence indicating the transmutation of elements.

Rutherford, in his studies, learned that the "emanation" from radium during its degradation through several steps to helium gives out an enormous amount of energy, vastly greater than in any process previously known to man. A comparative idea of this is had from calculations that have been made. A pound of the purest coal when burned in pure oxygen produces enough energy to lift its weight two thousand miles, or say from New York to Venezuela. A pound of hydrogen burned under similar conditions, a most violent chemical reaction, generates heat enough to lift its weight eight thousand miles, or, say, to Honolulu. A similar amount of radium, without any burning, produces enough energy to lift itself to the orbit of Neptune, or thirty times the distance from the earth to the sun. The decomposition of the emanation produces by far a greater portion of this energy. Surely such forces operating upon matter should cause events to come to pass with which man is unfamiliar. Indeed, he can scarcely foretell them, although Tyndall once said that "most molecules—probably all—are wrecked by intense heat, or in other words, by intense vibratory motion, and many are wrecked by a very impure heat of the proper quality." Herschel, in fact, as a result of his study of the temperature of the stars, remarked that the "atom has the stamp of a manufactured article."

When the emanation is placed in a dry vessel it breaks down into helium, as Ramsay, Soddy, and others have proved. Ramsay has just shown that when the emanation breaks down in the presence of water, neon, one of the five inert elements found by him in the air, is produced. When the emanation is allowed to break down in a solution of blue vitriol or copper sulphate, argon is the lazy gas produced. One of these is five and the other ten times as heavy as helium. We should expect the argon and neon thus produced to continue breaking down until helium is obtained. We have not been informed on this point as yet, but we do know that these elements obtained from other sources have not as yet been observed in such a temporary state.

The most remarkable part of Ramsay's observation, however, was concerned with the liquid left behind. When the copper was removed from the solution, lithium was detected in the residue by means of the spectroscope. This was not the case when copper was removed from a similar solution before treatment with the emanation. Gold, silver, copper, and lithium are members of one of the so-called chemical families. Lithium is the member with the least atomic weight, being one-ninth that of copper. Evidently, therefore, the powerful emanation had brought a degradation of the copper, and the element copper had been transmuted into the element lithium.

In justice to Ramsay it should be stated that he actually makes no real claim to what has generally been understood as transmutation. Especially does he maintain that his work has no connection with the current acceptation of the term, namely, the conversion of silver into gold. He calls it degeneration of one element into another. Now, silver is only a little more than half as heavy as gold, consequently such a conversion would be a reverse of his claims. It may be well to remind the reader that Emmens in this country made claim to this reverse process, and the claims were very widely heralded. The basis of Emmens's claims were as follows: Silver is 10.5 and gold 19.3 times as heavy as equal volumes of water. If by some mechanical device sufficient pressure could be exerted upon a definite volume of silver, so that it occupied one-half of its former volume, then we should have silver 19.3 times as heavy as an equal volume of water, the same as gold. This was called "argentaurum," a word coined from the Latin names for silver (*argentum*) and gold (*aurum*). Although it was claimed that the United States Mint accepted this "argentaurum" for gold at full price, we are not aware that it has played any part in changing the standard of values in commerce.

Can this emanation be Bacon's "philosopher's stone" reversed? If so, is there any way of taking the fairly abundant elements of comparatively low atomic weights, like calcium (from lime), aluminium (from clay), or copper even, and so saturate it with energy that it acquires properties like radium or platinum or gold?

Most writers on radium think such an accumulation of energy as shall be sufficient to build up that substance impossible, at least with our known agencies. The author, however, is not so sure of it from certain experiments not yet completed. A hundred years ago the telephone, with its present perfection, was a wild dream. Twenty-five years ago the communication of continent with continent without connecting wires was beyond comprehension. Fifteen years ago if any one had said we should soon be able to see the bony structure of the body through its fleshy covering and envelope of clothing, he would have been thought a fit and proper subject for an asylum. Yet, now we have the X-rays. Some wild dreams have come true. That, however, is no reason for assuming that all the pictures a fertile imagination may lay out are to become verities.—New York Times.

THE EARTH'S MAGNETIC AXIS.

The magnetic axis of the earth, and particularly the "magnetic north pole," appeals to the popular imagination. But the work of studying this axis is a difficult one, beset with complications. The Electrical Review sums up some recent investigations given in Terrestrial Magnetism and Atmospheric Electricity, by Dr. W. van Bemmelen, who deduces the position of the mean magnetic axis by means of a study of the magnetic declination alone. In the same issue, Dr. L. A. Bauer shows that if all the magnetic elements be considered, a result is obtained not in agreement with Dr. van Bemmelen's, and he then goes on to show why this is so. He first points out that Gauss's definition of the magnetic axis of the earth is the straight line about which the earth's magnetic moment would have a maximum value. If, then, the earth be uniformly magnetized, it will be possible to determine definitely the position of this imaginary line. However, not only is the magnetization heterogeneous, but it consists of two elements—internal forces and the external; and these vary independently of each other. Moreover, there is a third possible force affecting the magnetic distribution in the earth. This is magnetization caused by vertical earth-air electric current. There are therefore three elements to be considered, all of them independent, and in trying to locate the axis by means of these, different results will necessarily be obtained. In other words, the earth has three magnetic axes—one for each of the three component forces. From the surveys now being made in various countries it is to be hoped that much more will be known of the earth's magnetization than heretofore. But it is likely to be a long time before we come to any very clear understanding of the whole phenomenon.

MEXICAN BROMELIA FIBER.

Among the collections of fibers from tropical America shown at exhibitions has frequently appeared a long silky vegetable fiber of a greenish color, and showing great strength, though only an expert might particularly notice the small hanks into which the fiber is made up. When a specimen is unwrapped, however, the fineness of the fiber and its extraordinary length become apparent, for 6 feet is a common length. So strong is the fiber that it is difficult to break even a few filaments by direct strain without cutting into the hands. According to the Bureau of the American Republics, this is produced from the long narrow leaves of a "wild pine" belonging to the genus Bromelia. Its most common names are pita, pinuella, pinguin, and silk grass, though "pita" is meaningless, and silk grass is applied to so many other fibers that the name is worthless. The better names are pinuella and karatas. In the regions of Southern Mexico, from Oaxaca to Vera Cruz, where the plant grows in great profusion, the fiber is used largely for fine woven textures, where strength and durability are essentials, such as hunting bags and other forms of pouches. It is also used for sewing threads, and was formerly employed for sewing shoes. The fiber is cleaned by hand, and the great length of the thin narrow leaf, which is armed along its edges with sharp spines, makes it a tedious operation, hence the high price of the fiber. Efforts are being made to clean the leaves of the wild pineapple by machinery, and some fair examples of the fiber have been turned out experimentally in small quantities, so that future experiments are looked forward to with interest. The difficulty in the way of machinery extraction is largely due to the fineness and length of the leaf, a machine powerful enough to scrape off the hard epidermis inclosing the fiber layer being too harsh in its action, thus injuring the fiber. The production of well-cleaned, unbroken fiber by machinery, and in commercial quantities, would no doubt give to manufacturers a new textile which might enter into some of the present uses of flax, while the peculiar silkiness and the color of the fiber would adapt it to the manufacture of many beautiful woven articles, such as fancy bags, and even belts for summer wear. It would doubtless make superior fishing lines, and with further preparation and bleaching, it is probable that the fiber might be employed in a wide range of woven fabrics of great beauty. An Italian authority states that in Brazil and Guiana, where a similar (if not the same) plant abounds, the fine silk fiber is manufactured into many *articles de luxe*. In an old work on Mexico a species of Bromelia is referred to, which is said to yield a very fine fiber 6 to 8 feet long, "and from its fineness and toughness, it is said to be commonly used in belt-making work. It also finds application in the manufacture of many articles, such as baggings, wagon sheets, carpets, etc., besides being a valuable material for making nets, hammocks, cordage, and many other articles in common use." This undoubtedly refers to the common form of Bromelia. A species of short-leaved Bromelia grows in Paraguay and Argentina, producing a somewhat similar fiber, which is known as Caraguata, the product of *Bromelia Argentina*. The filaments from this species are rarely longer than 4 feet, and while the fiber is short and strong, it does not compare with the pinuella fiber from the regions of Oaxaca, Mexico. Bromelia fiber is closely allied to the famous piña, or pineapple fiber of the Philippines, from which are manufactured beautiful textures, such as fabrics for ball dresses, and handkerchiefs of gossamer fineness. There is said to be little doubt that with a careful preparation, some of the wild pineapple fiber might be employed in the same manner.—Journal of the Society of Arts.

The New York Electrical Show will be open from September 30 to October 9 at Madison Square Garden, New York city. Exhibits are expected from all the prominent electric manufacturing firms of this country, and from a few foreign ones. All kinds of apparatus will be shown, from heavy generating machinery to tiny incandescent lamps.

SCIENCE NOTES.

When the Coast Erosion Commissioners visited Walton on the Naze recently they were shown a spot north of the pier, and about a mile from the shore, which was formerly a churchyard. A quarter of a century ago the tombstones could be seen under water at ebb tide, but since then the sea has further encroached, and even when the tide is extraordinarily low and the sea clear the old burying ground is scarcely discernible from the sea level.—London Daily News.

The department of anthropology of the University of California has commenced recording the physical types of the Californian Indians. Measurements and photographs are taken, and it is hoped to make the physical record as complete as the one already compiled of their languages and myths. Mr. S. A. Barrett and Prof. A. L. Kroeber have already secured more than three hundred measurements from half a dozen of the principal tribes on the coast. It is intended to systematically cover the whole of the State, and ultimately to publish the results in an ethnological album of California.

The Greeks believed that the power of internal vision was enhanced by lack of bodily sight, according to Dr. Super in the Popular Science Monthly. This belief was in accordance with the law of compensation held by them. Fortune, good or ill, is always outweighed by its opposite. "The blind old man of Scio's rocky isle" was supposed to have been blind because his intellectual insight was preternaturally acute and accurate. Tiresias, the most famous seer in Greek legend, is always spoken of as blind. We do not know whether this preternatural acumen was the result of his want of sight or whether the latter was a condition precedent to the former. One of the favorite characters of Greek mythology was Œdipus, spending the sunset of his life in dignified retirement near Athens under the care of his daughter Antigone. In early years he had blinded himself after discovering that he had unwittingly been guilty of incest. The Greeks did but little by artificial light. They were early risers and all reputable people were supposed to retire early. Plato, in his Laws, says the master and mistress of the household should be the first to rise in the morning in order to show a good example to the other members. He further says: "Magistrates who keep awake at night are terrible to the bad whether enemies or citizens and are honored and revered by the temperate, and are useful to themselves." Throughout the entire ancient, medieval, and modern world, until within comparatively recent times, the badly lighted or totally dark streets made it a matter of prudence for honest people to go abroad as little as possible after nightfall, especially if they carried or were supposed to carry articles of value. The comparative sameness in the style of clothing gave the footpad the opportunity to replenish his wardrobe at the expense of his fellow without saying, "By your leave." We are not told that the man who went down to Jericho was attacked in the night, but we are informed that he was stripped. That the ancients placed a much higher value on worn garments than is done by the moderns is shown by the statement that the soldiers who kept guard over the body of Christ on the cross cast lots for his raiment. This was the custom at the execution of malefactors.

Though the art of making glass of certain kinds is very old, spectacles had to wait on the discovery or invention of some method that would produce it perfectly transparent. Specimens of glass have been found in the Egyptian tombs that are more than four thousand years old, and glass bottles are represented on tombs at least fifteen hundred years earlier. In Mesopotamia the art of making glass has been traced for at least two thousand years B. C. But all the glass of antiquity was of inferior quality and was almost useless for purposes where the rays of light were to be transmitted unbroken and with undiminished energy. Mirrors were also made in Egypt thousands of years before the Christian era. The materials used were obsidian, metal, zinc, and silver. Glass mirrors are mentioned by Pliny, but as they were neither perfectly plane nor foliated they gave back a very imperfect image and were not much esteemed. The word translated "glass" in King James's version is not as clear as in some of the later renderings. The passage in the First Epistle to the Corinthians, if read: "As yet we see things dimly, reflected as in a mirror, but then face to face," makes the sense plain. As looking-glasses, to use this term by anticipation, were generally made of steel or some other metal, they readily became tarnished, even when of the best quality; hence the man who beheld his face "in a glass" rarely got a distinct image, and thus would readily forget the lineaments of his countenance. That window glass, such as is now in common use, was slow to gain currency is shown by the little panes in many old buildings in Europe. They are usually round or nearly so, and so small that one of them can easily be held between the tips of the fingers and the thumb. That this form of window glass first came into vogue in Germany is evident from the name disk (Scheibe) by which a pane of glass is still designated, no matter what its shape.

ENGINEERING NOTES.

A concrete dike along the Ohio River to protect the flood district in Allegheny County, Pennsylvania, is being considered by the Mayor of Allegheny and the Director of Public Works. A dike 30 feet high and 20 feet wide at the top is contemplated, but of concrete, the gravel required being dredged from the bed of the river. This dredging of gravel would not only improve the channel, but would be an economy in construction. The cost is estimated at $5,000,000, most of which would come from property owners along the river front.

An English electrically-driven pumping station delivers from two 3,000,000-gallon reservoirs at the foot of a hill to an iron works at a higher elevation. The three three-throw pumps are driven by ropes from direct-current 500-volt motors of 120 horse-power each, two to each pump. Two 12-pole generators of 370 kilowatts each are driven each by two 250-horse-power engines, direct connected. Steam is furnished from boilers fired by spare gas from the furnaces. Each of the pumps is constructed with three rams, 18-inch diameter and 20-inch stroke. At 26 revolutions per minute they deliver 1,500 gallons under a head of 300 feet. To provide for easy removal of the armatures, the motor pulleys are placed on an independent shaft, attached to the motor shaft through a coupling.—Iron Age.

The Taylor's Falls plant, which is described in the Engineering Record, is a type of the hydraulic work of great economic importance now steadily under way. It is not at all sensational in capacity, voltage, or distance of transmission, but it is a fine example of a well planned and executed plant admirably constructed for economical and reliable service. Its most novel and interesting feature is the way in which the dam and power house are worked out together in massive concrete construction, giving a compact and convenient plant with the important feature of very short pen stocks, giving a most excellent opportunity for close regulation. The lesson it teaches is chiefly the economic one of the facility with which central stations can utilize water-power anywhere within a radius of many miles to keep down the cost of electrical energy. At the present time electrical power transmission involves little of difficulty and is settling down to standard forms of practice. The voltage of 50,000 used in this Taylor's Falls system would have been looked upon as rather hazardous even a few years ago. To-day it must be regarded as within the bounds of safe and conservative practice. In fact, one might almost say that 60,000 volts is now standard for large projects involving long transmissions, and 50,000 is certainly well within safe bounds. The question of reliability, which used so often to be raised with respect to long transmission, has now been pretty thoroughly settled in the affirmative. It is true that lines sometimes break down, but with well-constructed duplicate circuits the chance of actual failure of service is not a frequent one. Against it must be set off the fact that the chance of failure of the motive power is considerably less with water than with steam. Something may now and then go wrong even with a hydraulic plant, but there are fewer chances for little things to cause a shut-down than in a steam plant. It is a wise and far-sighted thing for a central station to develop hydraulic power for its own use and it nearly always pays from the start. Coal prices are upon the up grade and no return trains are running, so that what pays reasonably well now will be a splendid investment a few years hence. Plants like this at Taylor's Falls are permanent. They are certain to give many years of valuable service, and there is little likelihood that the apparatus will go out of date for the purpose of its use. The distributing appliances may change and the receiving end of the plant go out of date, but there is small probability that the generating station will become materially less economical as time goes on. Dynamos and waterwheels are unlikely to be materially improved in efficiency, and modern electrical machinery has a very long, useful life. As a matter of fact, the first polyphase generators put into operation in this country some fourteen years ago are still in successful operation, and generators as built to-day are even more durable. It pays to do a thing well, if at all, and plants built as thoroughly and planned as carefully as this one at Taylor's Falls are likely to justify the wisdom of their constructor for many years to come. As time goes on more and more of the larger central stations are likely to do likewise. Few can find power so near at hand as in Minneapolis, but transmissions of a hundred miles or more are now as safe and practicable as those of twenty or thirty miles a few years ago, and are not to be feared.

TRADE NOTES AND FORMULÆ.

Soap Leaves.—Ten parts by weight of glycerine, 30 parts of alcohol, 60 parts of dry glycerine soap, and 50 parts of ordinary neutral soap, constitute a mixture with which thin tissue paper is impregnated. This is effected in a trough, containing the mixture, which is kept at a temperature of 75 deg. to 82 deg. C. In the trough are disposed three rollers, driven by steam or other power, revolving in the same direction and over the lower side of which the paper is conducted. During this treatment the paper is wetted with a small quantity of oil of turpentine, which causes it to dry more rapidly and gives it an attractive polished appearance.

Manufacture of Tar-Color Copying Inks.—Blue: 1,000 parts water; 15 to 18 parts blue tar color soluble in water—alkaline blue, cotton blue; 15 parts gum arabic; 5 parts glycerine. Parts by weight. Violet: 1,000 parts water; 15 parts methyl violet; 15 parts gum arabic; 5 parts glycerine. Red violet: 1,000 parts water; 5 parts diamant fuchsine; 15 parts methyl violet; 15 parts gum arabic; 5 parts glycerine.

Hydrolith.—Hydrolith, as reported by Krull in the Journal für Angewandte Chemie, is a combination of hydrogen and calcium, and is obtained by the action of metallic calcium on a metal salt. From hydrolith, by the simple addition of water, hydrogen is said to be developed, just as from calcium carbide acetylene is generated when water is added. One kilogramme of hydrolith is said to yield 1,000 liters equals 1 cubic meter of hydrogen, and 1 kilogramme of chemically pure hydrolith yields 1,150 liters of hydrogen. Hydrolith will be chiefly employed for the production of hydrogen gas for filling balloons for military purposes.

Cements for Ivory.—1. To cement ivory pieces together, mix 1 part albumen with 1 part glue water. Or

2. Mix 1 part albumen with 3 parts of water or 3 parts of burnt gypsum, to a thin paste.

3. To cement small pieces of ivory to other substances, melt 1 part wax, 1 part rosin, and 1 part turpentine together, and with the melted mass mix 1 part mountain flax. Or

4. Two parts gutta percha and 2 parts of ordinary pitch are melted together, the parts to be cemented warmed, the cement applied, and the parts pressed together.

5. Dissolve 5 parts isinglass and 4 parts finest gilder's glue in 30 parts of water, warmed, evaporate the mixture to one-half its volume, and add 1/3 part mastic, dissolved in 1 part alcohol, and mix in, while stirring, 1 part zinc white. The cement is applied warm to the warmed parts; it dries very quickly and soon becomes hard, but can be kept for a long time in a closed receptacle.

Directions for Making Deep Black Stamping Inks.—1. An excellent stamping ink which will not run and gives fine impressions is made of 15 parts finest lamp black, 6 parts gum arabic, 6 parts glycerine, 4.6 parts water. Parts by weight. First the gum arabic, dissolved in water, is mixed with the glycerine, and in order to remove possible impurities, which occur in the best grades of gum arabic, the mixture is filtered through a linen cloth. The clear fluid is then incorporated, on the rubbing stone, in a grinding dish or in the paint mill, with the lamp black to form an even mass, which owing to the glycerine will not dry out and becomes solid, but furnishes good impressions that will not smear.

2. In the following manner we can make a stamping ink equal in blackness and brilliancy to the best printing ink, impressions of which on paper rapidly dry without the inking pad hardening or drying: 150 parts tannin black, 150 parts water, 300 parts glycerine. Dissolved in the sand bath or water bath, the solution being assisted by frequent stirring. The finished ink is a fluid of syrupy consistency that neither settles nor molds and can be kept a long time for use as needed.

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